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RADIATION DATA AND REPORTS

Volume 14, Number 10, October 1973

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

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U.S. ENVIRONMENTAL PROTECTION AGENCY
Russell E. Train, Administrator

Reports

A History and Preliminary Inventory Report on the Kentucky Radioactive Waste Disposal Site[1]

David T. Clark[2]

The Kentucky radioactive waste disposal site, operated by the Nuclear Engineering Company, Incorporated, has been in operation since March 1963. As of January 1, 1972, approximately 0.71 million cubic meters of waste, containing 1,153,333 curies of byproduct material, 208,903 grams of special nuclear material, and 39,493 kilograms of source material, have been disposed of at this facility. Due to the relatively long period of operation and the large quantities of radioactive material involved, a detailed inventory of two of the largest pits at the site was made, based on available disposal records. This report contains a brief history of this facility and a summary of the inventory results.

In March of 1962, the State of Kentucky, through enabling legislation passed by the 1960 General Assembly, entered into agreement with the United States Atomic Energy Commission (AEC) to assume regulatory powers relating to the licensing of radioactive materials. In this agreement, authority was vested in the State to license the disposal of radioactive waste. The AEC retained authority to license the burial of high level waste resulting from the reprocessing of spent nuclear fuel.

With the primary intention of encouraging nuclear industry in Kentucky, the Kentucky Atomic Energy Authority pursued the concept of a radioactive waste disposal site in the State. Nuclear Engineering Company, Inc. (NECO), whose home office is in Walnut Creek, Calif., submitted an application to the Kentucky Department of Health for a license to bury radioactive waste at a proposed site in Fleming County, Ky. The Department of Health made an extensive and detailed review of the submitted application. Included in this detailed review was a comprehensive evaluation of the proposed site by the U.S. Geological Survey and the Kentucky State Geological Survey. Also assisting in this evaluation were the Oak Ridge National Laboratories, the U.S. Atomic Energy Commission, the U.S. Public Health Service (PHS), an independent geologist hired by the Nuclear Engineering Company, Inc., and a geological testing firm. The studies conducted by this evaluation team included geological, hydrological, and meteorological aspects. In addition, radiological studies were made of the natural radioactivity existing in the area in order to establish a baseline. It was concluded by this group that the site in Fleming County, known as Maxey Flats, located approximately 16 kilometers northwest of Morehead, was suitable for the disposal of solid radioactive waste.

As a result of this site approval based on the referenced evaluation, a license was issued for the disposal of solid byproduct, source, and special nuclear materials at the proposed site provided that the title of this site was conveyed to the Commonwealth in accordance with KRS 162.693 and Title 10 of the Code of Federal Regulations, Part 20.302.

In January 1963, a contract was negotiated between the Kentucky Atomic Energy Authority and the Nuclear Engineering Company, Inc., to operate a commercial radioactive waste disposal facility at the Maxey Flats site. This site encompasses approximately 1.3 x $10^6 m^2$. The land originally was acquired by the Nuclear Engineering Company and the title to the land transferred to the State of Kentucky. The Kentucky Atomic Energy Authority, in turn, leased the tract of land to the Nuclear Engineering Company for a period of 25 years with the option to renew the lease for another 25-year period thereafter.

---

[1] This project was made possible through a United States Environmental Protection Agency—Kentucky State Health Department contract.

[2] Radiological Health Program, Kentucky State Department of Health, 275 East Main Street, Frankfort, Ky. 40601.

For the perpetual care of this site, the lease agreement contained a clause stating that the Nuclear Engineering Company would pay to the State of Kentucky a negotiated price per cubic foot of waste not to exceed 4 percent of the average burial charge per cubic foot charged by the licensee.

Under the conditions of the original license issued October 22, 1962, the licensee was restricted to the following possession limits for unburied radioactive material: (1) 400 curies of byproduct material; (2) 350 grams of special nuclear material; and (3) 907 kilograms of source material.

Through amendments to the original licenses over the years, the present license imposes the following limits.

License condition 8

The licensee shall not receive and possess at any one time unburied radioactive material in excess of:

(a) 5,000 curies of radioactive material excluding source and special nuclear materials;
(b) 4,500 kilograms of source materials;
(c) 350 grams of uranium-235, 200 grams of uranium-233, 200 grams of plutonium; or any combination of them in accordance with the following formula: for each kind of special nuclear material, determine the ratio between the quantity of that special nuclear material and the quantity specified above for the same kind of special nuclear material. The sum of such ratios for all kinds of special nuclear material in combination shall not exceed unity; and
(d) the licensee shall not receive or possess at any one time a quantity of radioactive material in excess of that specified in Paragraph 8.a., unless the agency has first evaluated the proposed packaging, handling and burial procedures, determined that the proposed operations can be accomplished without undue risk to the health and safety of occupationally exposed individuals and the public, and issued an authorization letter.

The provisions of condition 8.d. have been used numerous times by the company (appendix 1).

Even though the above restrictions are imposed on the amount of material that can be received per shipment and/or stored at Maxey Flats, the types of radioactive material as well as the total quantity that may be buried are essentially unlimited. Most of the solid wastes are buried in rectangular trenches approximately 110 meters long, 21 meters wide, and 6 meters deep. Initially, these trenches were described as being approximately 76 meters long, 6 meters wide and 6 meters deep. Through December 1971, there have been 23 of these trenches constructed and filled (appendix 2). The floor of the trench is to have a slope of approximately 1 degree to a sump and stand pipe positioned at the lowest level. Gravel drains were initially required but discontinued when it was considered that random dumping provided adequate voids for migration of infiltrants to the sumps. Most wastes are randomly dumped in the pit beginning at the high end and backfilling as required to reduce radiation levels. The radiation level at the surface of the earth above the completed pits is not allowed to exceed 2 mR/h. Levels around the open pits are not allowed to exceed 100 mR/h.

Each completed trench is required to be backfilled with a minimum of 1 meter of earth materials mounded and compacted to form and maintain an "umbrella" to seal out ground water to the greatest extent possible and to divert rain water away from the trench. Following settling, a shallow rooted crop is to be planted to prevent erosion.

Finally, a monument is placed at the end of each pit and inscribed with the number of the pit and date of closure. This is to provide a reference to the records (appendix 3), which contain the following additional required information:

(a) location and definition of trench boundary;
(b) total activities of radioactive material in curies excluding source and special nuclear materials, total amount of source material in kilograms, and total amount of special nuclear material in grams in the trench;
(c) radionuclides with greatest hazard potential;
(d) date of completion of the burial operation; and
(e) volume of waste in trench.

During most of the use of this facility, the bulk of the liquids have been solidified using cement and newspaper. The concrete and paper mixture was buried in trenches lined with polyethylene. When the trench was filled, the polyethylene was lapped over the top and capped as previously described. The solidified liquids have been buried in separate pits of which 11 have been constructed and filled as of the end of 1971. As of January 1, 1972, NECO had solidified and disposed of 2,243,230 liters of liquid radioactive waste. As can be seen from the table in appendix 4, there had been no significant increase in amounts of liquids disposed until 1971, when 1,286,660 liters were disposed of at this site. This dramatic increase in disposal rates is attributable almost solely to the nuclear power reactor industry and is due to the present philosophy of "Zero Release."

Generally, high specific gamma activity sources are not buried in the large trenches since they would create an exposure problem for personnel during dumping and filling operations. These wastes, if sufficiently small in size, are deposited in special hot wells constructed about 4.6 meters deep with pipes of coated steel, concrete, or tile placed vertically in the ground and closed at the lower end and capped at the upper end. When the number of sources or the radiation level renders it inappropriate to place additional materials in the pipe, the pipe is filled with concrete. There are eight such wells on site and seven have been sealed.

Other high intensity sources of larger volume, such as resins from reactor facilities, are placed in individual pits approximately 9 meters long by 3 meters wide by 3 meters deep. A sump pipe is placed in each of the pits for monitoring and water removal.

The first radioactive material was buried at this site in May 1963. Early preliminary estimates were based on an assumed burial rate of waste at this site of approximately 750 curies per year. It soon became evident that this was a gross underestimation, for in 1963, 2,206.0 cubic meters of waste containing 22,556 curies of byproduct material were disposed of at this site. As of January 1, 1972, approximately 0.71 million cubic meters containing 1,153,333 curies of byproduct material, 208,903 grams of special nuclear material and 39,493 kilograms of source material have been disposed of at this site. The annual and cumulative rates are shown graphically in appendix 5. The cumulative volume of material buried has increased almost exponentially, with the amount of special nuclear material buried doubling approximately every 1.3 years.

There is no specific exclusion of hazardous toxic materials at this time, provided that they are in association with potentially hazardous radioactive materials. However, on October 16, 1970, the Nuclear Engineering Company, Inc., was notified that a request by them, dated September 16, 1970, for a solid waste disposal permit for the disposal of nonradioactive, hazardous, toxic or dangerous wastes at their site at Maxey Flats would not be issued. The Solid Waste Program and the Division of Environmental Health, in a joint meeting, had determined that the granting of such a permit would not be in the best public interest.

At this time, no provision has been made to document chemical form or type of material; however, the following interim policy was adopted on June 2, 1972 by the Kentucky Radiological Health Program regarding the burial of radioactive material in combination with chemically toxic waste:

> "When waste contains both radioactive materials and toxic chemicals, the potential hazard of both will be evaluated independently. The waste containing both radioactive material and chemical toxic waste will

> not be accepted for burial at the Kentucky radioactive waste disposal site, if the chemical hazard exceeds the radiological hazard. The determination of the hazard will be performed by the Radiological Health staff after consultation with toxic chemical experts. As a guide in making this evaluation, any toxic chemical falling in Category 3 listed in the manual "Dangerous Properties of Industrial Materials," 1968, by Irving Sax, shall be considered more hazardous than its associated radioactive material, until it is determined by the staff that this is not the case."

This policy was adopted as an interim policy only. It is strongly recommended that this problem be better defined by experts in the field of radiation safety, solid waste management, toxic chemical experts, and other appropriate persons knowledgeable of the problems involved. It is further recommended that a national position be established for all radioactive waste disposal sites throughout the United States.

The disposal records maintained by NECO include the following information:

(1) the date of receipt;
(2) the physical state (solid, liquid, or gas);
(3) the principal radioisotope;
(4) the activity; and
(5) the customer.

The company is also able to identify the pit and approximate location where each shipment is buried.

Due to the relatively long period of operation and large quantities of radioactive materials disposed of at this site, the Kentucky Radiological Health staff initiated a study to determine the current inventory of specific radioactive materials at the Kentucky NECO waste disposal site. Prior to June 1970, all radioactive shipment records (RSR) had been filed according to customer's name with a separate file maintained to indicate pit placement. After this date, all RSR's have had the pit into which the shipment was placed noted on them and filed by pit number. With this information it was decided to first compile an inventory of the two pits completed since this policy went into effect.

The first pit inventory to be completed was for pit no. 30. This pit was opened in June 1970 and closed February 1971. According to the monthly burial reports submitted by the licensee to the Agency, pit no. 30 contained 23,940 curies of byproduct material, 48,713 grams of special nuclear material, and 6,471.9 kilograms of source material. The total combined volume of all radioactive waste buried in pit no. 30 was 8,984.41 cubic meters.

For the purpose of analyzing the byproduct material components within the pits, the staff arbitrarily chose five specific nuclides for identification. These nuclides included cesium-137, strontium-90, cobalt-60, tritium, and radium-226. They were chosen because of their significant biological effect and relatively long half-lives. The total activity for each chosen nuclide and the percent of the total buried activity in pit no. 30 is shown in table 1.

Table 1. Radioactivity of selected nuclides buried in pit no. 30, Maxey Flats

Radionuclide	Activity[a] (curies)	Percent of total byproduct activity
Cesium-137	343.96	1.4
Strontium-90	988.47	4.1
Cobalt-60	7,218.66	30.2
Tritium	414.7	1.7
Radium-226	.292	<1

[a] Initial activities—activities as recorded on the original shipment forms.

In addition to the identification by the five referenced specific nuclides, a second broad category was identified. This category is defined as mixed fission products (MFP). This category includes items identified on the shipping records specifically as mixed fission products, and additionally, includes items shown on the shipping records for which only one activity is shown for a multiradionuclide combination. An example of the latter case is: iodine-131, tritium, and zinc-65 - 10 mCi.

Probably the most significant finding of this study is the amount of MFP buried at this site. The records indicate that 10,329.91 curies of MFP were buried in pit no. 30. This represents 43.2 percent of the total byproduct material in the pit.

The remaining 19.4 percent of 4,644 curies of byproduct material in pit no. 30 is made up of very short half-life material received from

6

academic and medical institutions (technetium-99m, iodine-131, etc.).

In addition to an analysis of the byproduct material, a determination was made of the plutonium-239 buried as special nuclear material. Of the total 48,713 grams of special nuclear material in pit no. 30, 2,155.48 grams were identified as plutonium-239.

The effective half-life for the byproduct material contained in pit no. 30 was calculated. This calculation was based on the half-lives of the five identified radionuclides and an estimated half-life of 1.6 years for mixed fission products. For a discussion of the calculation of the effective byproduct half-life for pit no. 30, see appendix 6.

The special nuclear material and source material buried in this pit were not included in the calculation. It is obvious that the effective half-life, if special nuclear material and source material were included, would be in the thousands of years. From a public health consideration, one would consider plutonium-239 as being the most hazardous material in this category, and therefore a half-life for special nuclear material and source material could be assigned as 24,390 years.

The second pit inventory that was completed was pit no. 32, which was opened in September 1971 and closed in May 1972. According to the monthly burial records submitted by the licensee to the agency, pit no. 32 contained 28,310 curies of byproduct material, 54,327 grams of special nuclear material, and 9,436.5 kilograms of source material. The total combined volume of all radioactive waste buried in pit no. 32 was 8,436.65 cubic meters.

The specific byproduct material identification in pit no. 32 is shown in table 2.

In addition to the above five nuclides, the amount of byproduct material identified as MFP in pit no. 32 was 13,618 curies representing 48 percent of the total byproduct material in the pit.

The remaining 25.5 percent or 7,219 curies of byproduct material is made up of short half-life nuclides.

For pit no. 32, of the total 54,327 grams of special nuclear material, 12,966 grams of plutonium-239 were identified.

Table 2. Specific byproduct material identification in pit no. 32, Maxey Flats

Radionuclide	Activity (curies)	Percent of total byproduct activity
Cesium-137	299.18	1
Strontium-90	562.0	2
Cobalt-60	4,673.0	16.5
Tritium	2,063.0	7
Radium-226	8.0	<1

The byproduct half-life for pit no. 32 was also calculated (appendix 7).

During the course of this inventory study, we have accumulated additional information on seven other pits. As can be seen by the tabulation in appendixes 8 and 9, this information is not complete and will require much additional time to complete.

The tabulation in appendix 9 is only a partial listing of company inventories. A complete listing will be completed in the future. The following paragraphs contain a summary of some of the information resulting from the study so far.

Company I is a major contributor to the large quantities of special nuclear material disposed of at this site. Our study of the records show that this company through December 14, 1971 disposed of 90,299 grams of special nuclear material, and 3,086 grams of plutonium-239.

Company J, as of September 28, 1971, had shipped for disposal to the Nuclear Engineering Company, 140,282 curies of radioactive byproduct material. Of this quantity, 122,418 curies was not identifiable as to specific isotopes. The record showed that most of their waste was listed as mixed fission products (appendix 11).

Many irregularities were encountered in the course of this study. We have found that the Nuclear Engineering Company has accepted shipments where the RSR's included activity or isotopic designations that the company did not understand. (Examples: Plutonium-238 in UCC, D-38 Tuballoy oxide, etc.). There were several RSR's encountered in this study which would indicate that the Nuclear Engineering Company, Inc., had received and disposed of non-radioactive chemical waste at the Kentucky waste disposal site.

Recommendations

This pilot inventory has shown the need for an improved record-keeping system for the accountability of radioactive waste. The information obtained during this study has shown a definite need to continue a complete inventory of the Kentucky radioactive waste disposal site. Therefore, the first recommendation is that efforts be made to continue the inventory study of the Kentucky site.

As a result of this pilot study, the following specific recommendations are made to improve the records system for the accountability of radioactive waste.

(1) All burial records should be on a form which can be handled by automatic data processing equipment.

(2) All commercial waste disposal facilities should adopt a uniform format for disposal of waste.

(3) The format for collecting the data should include the following:

- (a) The specific radionuclide.
- (b) The activity in curies for byproduct material and naturally occurring or artificially produced materials.
- (c) The weight of special nuclear material in grams and specifically, the plutonium-239 in grams.
- (d) The weight of source material in kilograms.
- (e) The chemical composition of each shipment. The identification of the chemical composition normally specifies the elemental composition. This should be done when possible; however, with some shipments, e.g. carcasses, it is impossible to identify the elemental composition, such as a carcass. For shipments in which the elemental composition cannot be identified, the shipper should identify the shipment by the name of the item being shipped.
- (f) The most chemically toxic material associated with the radioactive waste and the concentration of this toxic material.

(4) A requirement by the licensing agency of the disposal facility that the shipment be rejected, if the shipper has not identified the waste as described above.

(5) Regulatory agencies should inspect more closely the records of disposal of each licensee for compliance with their regulations on waste disposal record-keeping.

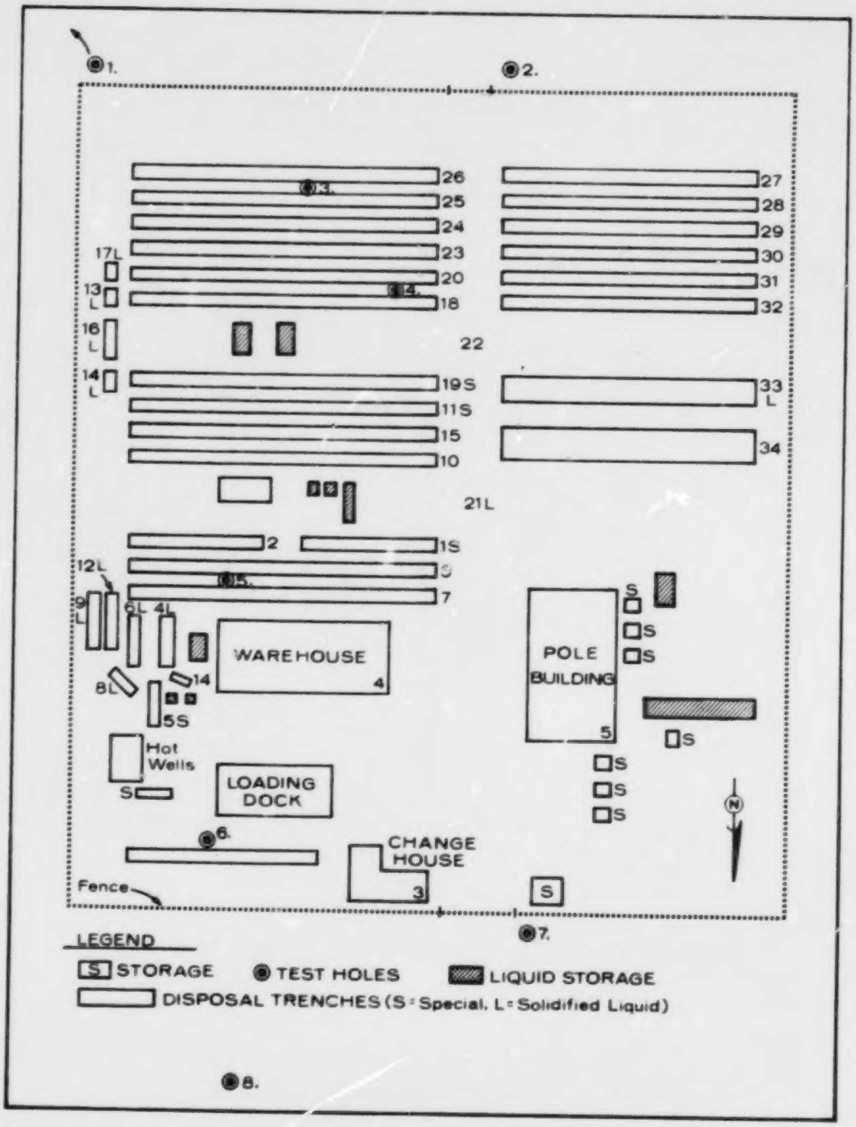
Much of the data in this report was taken from an unpublished report by Joel G. Veater, EPA Region IV (Atlanta, Ga.) and David T. Clark, Kentucky State Department of Health, Frankfort, Ky.

APPENDICES

Appendix 1. Special authorizations for burials exceeding the limits of the Kentucky waste disposal license

Date	Material buried	Radioactivity (curies)
June 26, 1972	Mixed fission products	20,613
April 27, 1972	Irradiated steel tube and control rod	17,000
April 19, 1971	Tritium	645,4[illegible]
February 25, 1971	Cobalt-60	31,867
November 15, 1966	Cobalt-60	20,000

APPENDIX 2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Hot Wells
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LOADING DOCK
POLE BUILDING 5
S
CHANGE HOUSE 3
Fence
N
LEGEND
S STORAGE
● TEST HOLES
▨ LIQUID STORAGE
DISPOSAL TRENCHES (S=Special, L=Solidified Liquid)

Figure 1. Sketch of Maxey Flats radioactive waste disposal facility

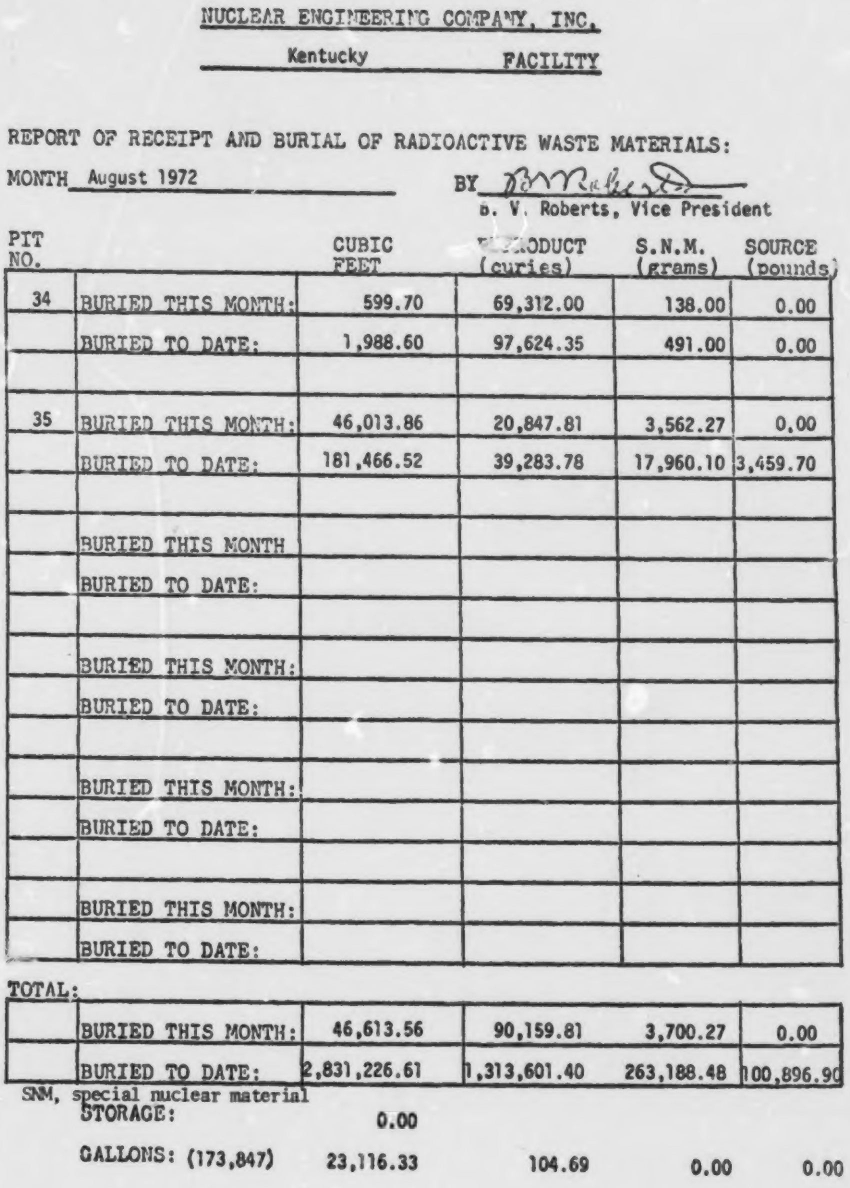
APPENDIX 2

Appendix 2. Specific pit information

Pit number[a]	Date closed	Cubic feet	Byproduct (curies)	Curies per cubic foot	Special nuclear material (grams)	Source material (pounds)
1	5/63	16,307	409	0.025	28	651
1a	10/63	3.752	2,254		1	0
2	7/63	18.073	82	4.54	59	15
3	10/63	24,409	11,343	.46	435	10,737
4	10/63	749	0		0	0
5a	4/64	7,015	13,173	1.88	405	5
6L	11/63	603	11	.018	0	3
7	4/64	34,722	24,490	.705	1,614	1,130
8L	1/64	2.246	.05		0	0
9L	3/64	1,520	.02		0	0
10	12/64	82,227	107,762	1.31	8,083	11,070
11	9/65	62,630	9,834	.157	2,566	1,064
12L	7/64	839	1		0	0
13L	9/64	749	.01		0	0
14L	6/66	400	.05		0	0
15	9/65	92,7[illegible]3	41,829	.45	1,628	188
16L	4/65	709	8		0	0
17L	12/65	3,613	14		0	0
18	2/66	66,149	15,116	.228	1,830	12
19a	12/66	93,110	27,314	.293	3,834	495
20	11/66	96,629	24,201	.25	3,198	1,016
21L	10/71	22,780	132		2,240	640
22	1/72	1,689	35,122	20.794	8	0
23	6/67	113,178	18,533	.163	4,957	2,283
24	10/67	92,670	4,563	.049	1,598	297
25	1/68	71,103	8,271	.116	5,169	4,282
26	5/68	91,038	14,437	.158	5,917	689
27	2/69	224,334	22,591	.10	11,638	12,904
28	9/69	209,898	11,719	.055	21,473	5,335
29	6/70	270,746	27,513	.10	13,427	1,890
30	2/71	317,282	23,940	.07	48,713	14,268
31	10/71	280,549	666,344	2.36	46,476	2,208
32	5/72	297,938	28,310	.095	54,327	20,804
33L	1/72	27,950	43		0	0
HW1	1/64	8	4,661	582.63	0	0
HW2	4/66	29	1,289	44.45	0	0
HW3	11/66	37.5	1,224	32.64	0	0
HW4	10/67	12	17	1.42	0	0
HW5	2/68	40	602	15.05	285	0
HW6	5/68	71	784	11.04	346	0
HW7	12/70	9.35	1,971	210.80	0	0
HW8	3/71	14.8	249,310	16,845.27	0	0

[a] a-special pit.
L-solidified liquid waste pit.
HW-hot well.

APPENDIX 3



NUCLEAR ENGINEERING COMPANY, INC.

Kentucky FACILITY

REPORT OF RECEIPT AND BURIAL OF RADIOACTIVE WASTE MATERIALS:

MONTH August 1972

BY

B. V. Roberts, Vice President

PIT NO.		CUBIC FEET	BY-PRODUCT (curies)	S.N.M. (grams)	SOURCE (pounds)
34	BURIED THIS MONTH:	599.70	69,312.00	138.00	0.00
	BURIED TO DATE:	1,988.60	97,624.35	491.00	0.00
35	BURIED THIS MONTH:	46,013.86	20,847.81	3,562.27	0.00
	BURIED TO DATE:	181,466.52	39,283.78	17,960.10	3,459.70
	BURIED THIS MONTH				
	BURIED TO DATE:				
	BURIED THIS MONTH:				
	BURIED TO DATE:				
	BURIED THIS MONTH:				
	BURIED TO DATE:				
	BURIED THIS MONTH:				
	BURIED TO DATE:				

TOTAL:

	BURIED THIS MONTH:	46,613.56	90,159.81	3,700.27	0.00
	BURIED TO DATE:	2,831,226.61	1,313,601.40	263,188.48	100,896.90

SNM, special nuclear material

STORAGE:	0.00			
GALLONS: (173,847)	23,116.33	104.69	0.00	0.00

Figure 2. Report of receipt and burial of radioactive waste materials

APPENDIX 4

Appendix 4. Disposal of solidified liquid radioactive waste material at the Nuclear Engineering Company facility

Year	Yearly rate (gallons per year)	Cumulative total (gallons per year)
1963	18,514	
1964	31,624	50,138
1965	32,325	82,463
1966	22,047	104,510
1967	30,590	135,100
1968	55,497	190,597
1969	44,762	235,359
1970	20,009	255,368
1971	339,936	595,304

APPENDIX 5

Appendix 5. Nuclear Engineering Company burial rates

Year	Cubic feet	Byproduct (curies)	Curies per cubic foot	Special nuclear material (grams)	Source material (pounds)
1963	77,905	22,556	0.29	959	11,487
1964	136,736	147,218	1.1	11,770	12,333
Cumulative total	214,641	169,774		12,729	23,820
1965	203,129	63,828	.31	4,261	1,252
Cumulative total	417,770	233,602		16,990	25,072
1966	196,205	52,737	.27	7,462	1,521
Cumulative total	613,975	286,339		24,452	26,593
1967	276,158	23,272	.08	14,842	12,516
Cumulative total	890,133	309,611		39,294	39,109
1968	288,757	45,578	.16	17,771	13,772
Cumulative total	1,178,890	355,189		57,065	52,881
1969	365,596	31,028	.09	31,506	5,631
Cumulative total	1,544,486	386,217		88,571	58,512
1970	442,128	56,969	.13	47,562	15,913
Cumulative total	1,986,615	443,186		136,133	74,425
1971	465,145	710,147	[a] .14	72,770	12,643
Cumulative total	2,451,759	1,153,333		208,903	87,068

[a] This figure does not include a single shipment of 645,000 curies of tritium.

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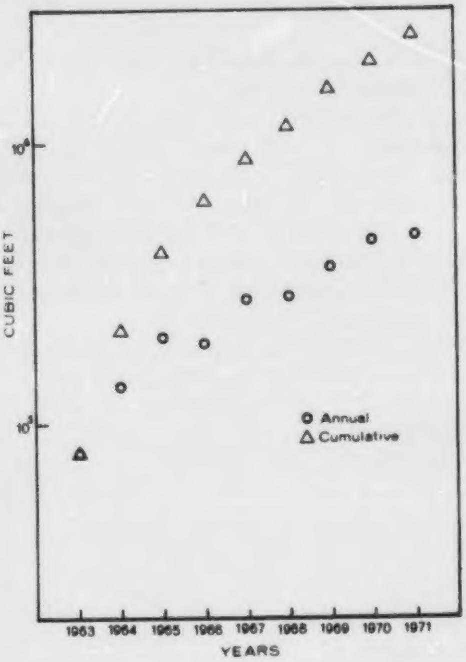

Figure 3. Burial of radioactive waste material (cubic feet per year)

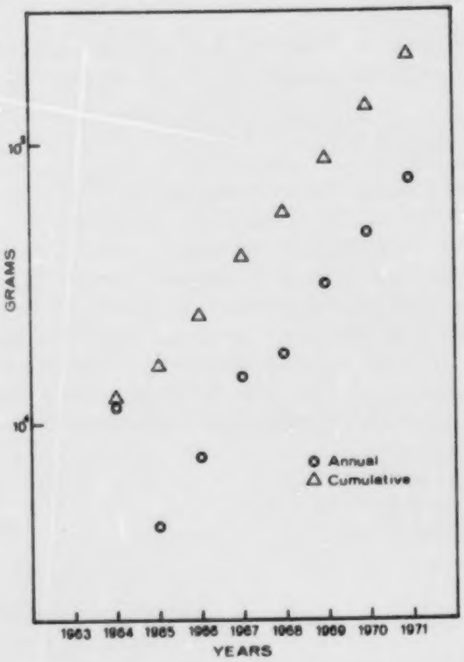

Figure 4. Burial of radioactive waste special nuclear material

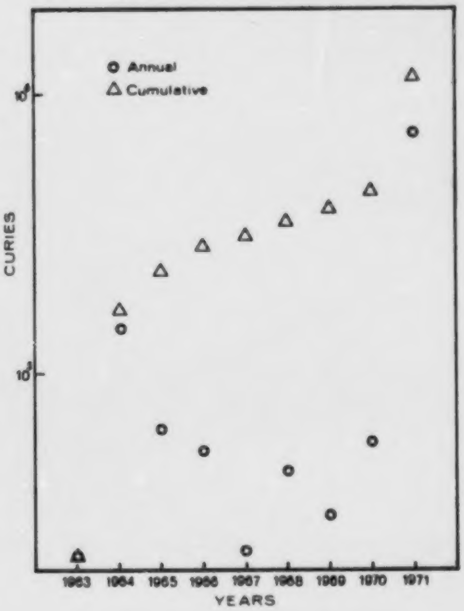

Figure 5. Byproduct material

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APPENDIX 6

Appendix 6. Effective half-life for byproduct material component of pit number 30

For purposes of determining the effective half-life of the byproduct component in this pit, it was necessary to assign a half-life to the mixed fission products included in the byproduct material component. As indicated in this report, mixed fission products include a broad category of unidentified material. For purposes of this calculation, a half-life for mixed fission products of 1.6 years was determined from the *Radiological Health Handbook*, September 1960 edition, pages 98 and 99.

Using the activity-time relationship of the five identified nuclides and the mixed fission product component, a decay curve was calculated. Although the curve for pit number 30 was not completed in time for this report, the first indications were that the slope of the curve followed almost identically the curve determined for pit number 32 (appendix 7).

From this calculated curve, it can be observed that the first effective half-life is 2.6 years for pit number 32, and apparently, also for pit number 30.

APPENDIX 7

Appendix 7. Effective half-life for byproduct material component of pit number 32

The calculated effective half-life curve for the byproduct component in pit number 32 is shown below. The calculated curve for pit 32 and pit 30 appeared to be identical.

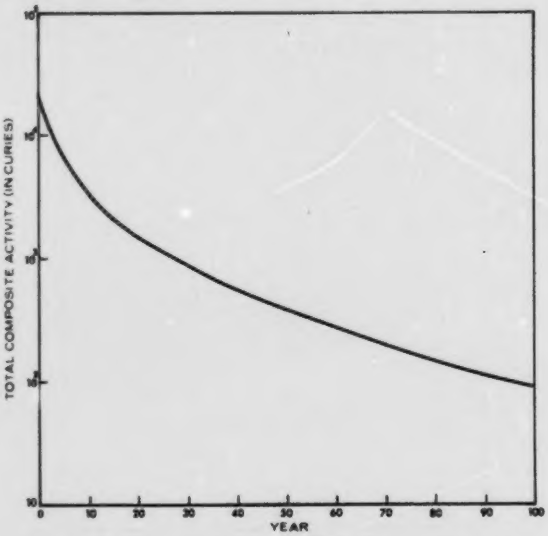

Figure 6. Curve showing activity-time relationship of total composition activity buried in pit number 32

APPENDIX 8

Appendix 8. Summary of pit inventories

Pit number	Not specifically identifiable [a] (curies)	Special nuclear material (grams)	Plutonium-239 (grams)	Radioactivity (curies)			
				Cobalt-60	Strontium-90	Radium-226	Tritium
21L [b]	5.943						
22	154.141			78.8			
30 [c]	14,606.286	47,114.33	1,730.36	4,554	115.1	6.339	794.6
31	3,824.933	5,836.92	829.26	1,734		10.935	42.7
32 [c]	13,618.395	53,753.94	12,966.29	4,673	562.9	58.003	2,062.7
33L [b]	3.457			3.7			31.2
34	23,805.866			1,200			
35	362.227	3,168.20	508.41	1,923	2.5	.021	15.75

[a] This group includes mixed fission products and listings that had more than one radioisotope associated with a given activity.
[b] L-solidified liquid waste pit.
[c] Completed inventory.

APPENDIX 9

Appendix 9. Summary of completed company inventories

Company	Not specifically identifiable [a] (curies)	Special nuclear material (grams)	Plutonium-239 (grams)	Radioactivity (curies)			
				Cobalt-60	Strontium-90	Radium-226	Tritium
A	74.088	0.10		95,259	40.2	0.056	57.7
B	1.290						51.5
C	4.154						
D	569.249			1,977		.02	205.7
E	.094	1,536.7		.70		.01	
F	.480						
G	3,885.874			987		.074	41.24
H	614.415			19,727	2.0		4.0
I	64.025	90,299.23	3,086.08	11.4	.67		
J	122,418.375	246.45	17,618.45	8,010			
K	347.055	6,679.58		1.5			19.0
L	.410						
M	.030					.010	
N	2,027.330			9.1			22.6

[a] This group includes mixed fission products and listings that had more than one radioisotope associated with a given activity.

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Data

SECTION I. MILK AND FOOD

Milk Surveillance, June 1973

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—7 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radio-

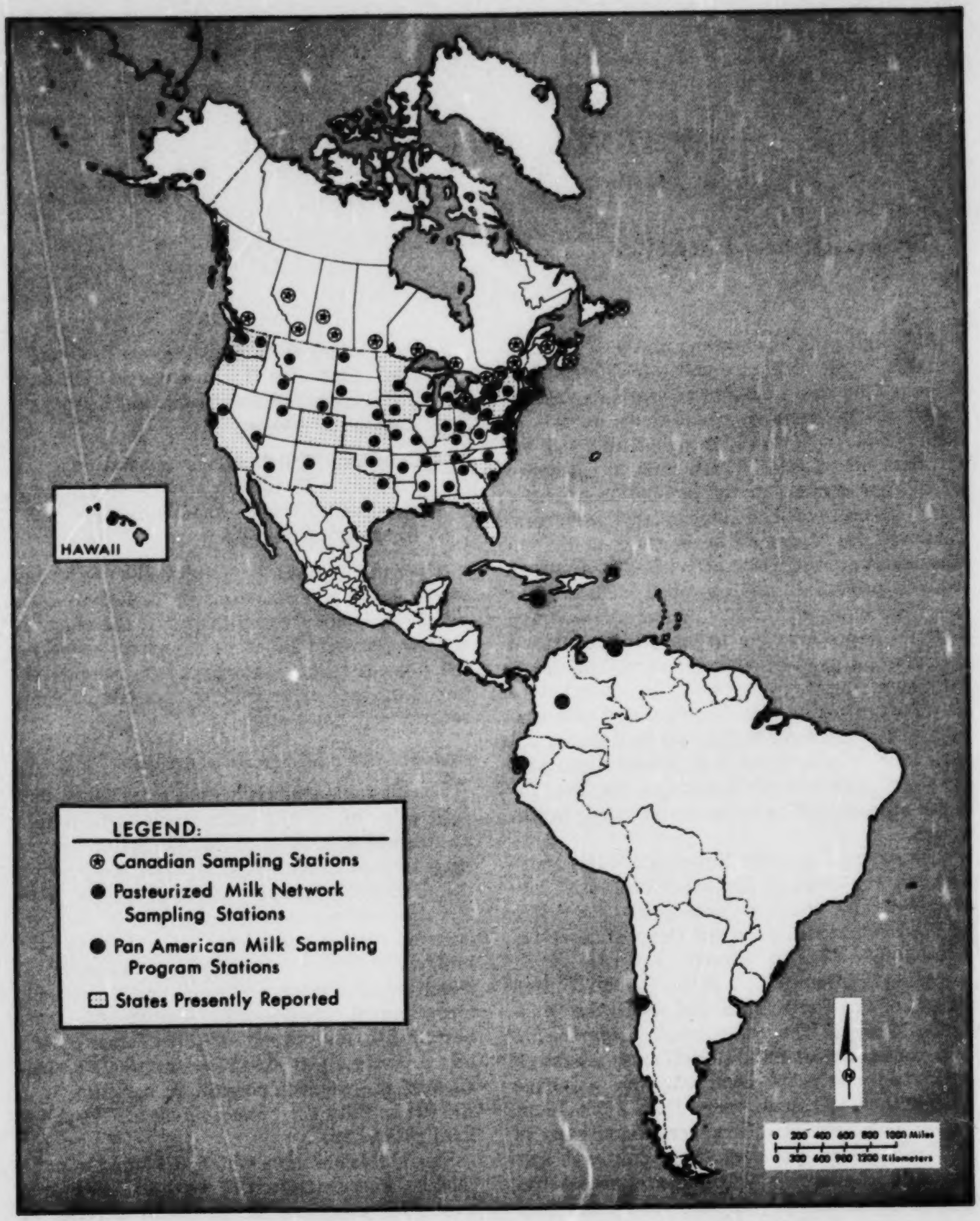
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
● Pan American Milk Sampling Program Stations
▨ States Presently Reported
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers

Figure 1. Milk sampling networks in the Western Hemisphere

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strontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during June 1972 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 18 laboratories producing data for the networks reporting in *Radiation Data and Reports*, 14 participated in the study.

The accuracy results of this study for these 14 laboratories are shown in table 1. The accuracy of the cesium-137 measurements continues to be excellent as in previous experiments. However, both the accuracy and precision need to be improved for iodine-131, strontium-89, and strontium-90 which could probably be accomplished through recalibration.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The

Table 1. Distribution of mean results, quality control experiment

Radionuclide and known concentration	Number of laboratories in each category				Experimental 2σ error (pCi/liter)
	Acceptable [a]	Warning level [b]	Unacceptable [c]	Total	
Iodine-131 (96 or 99 pCi/liter)	7 (58%)	1 (8%)	4 (33%)	12	6
Iodine-131 (438 or 484 pCi/liter)	11 (85%)	0	2 (15%)	13	25 or 28
Cesium-137 (53 or 54 pCi/liter)	11 (92%)	0	1 (8%)	12	6
Cesium-137 (295 or 303 pCi/liter)	11 (85%)	2 (15%)	0	13	17
Strontium-89 (29 or 30 pCi/liter)	9 (82%)	0	2 (18%)	11	6
Strontium-89 (197 or 201 pCi/liter)	3 (33%)	1 (11%)	5 (56%)	9	11 or 12
Strontium-90 (32.1 or 32.4 pCi/liter)	4 (33%)	4 (33%)	4 (33%)	12	1.9
Strontium-90 (150.5 or 151.2 pCi/liter)	6 (55%)	0	5 (45%)	11	8.7

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

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number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*6*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error of precision expressed as pCi/liter or percent in a given concentration range has also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥ 50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥ 20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥ 100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiation Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the February 1973 issue of *Radiation Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported in *Radiation Data and Reports*. The relationship between the PMN stations and the State stations is shown in figure 2. The first column in table 2 under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to

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Table 2. Concentrations of radionuclides in milk for June 1973 and 12-month period July 1972 through June 1973

Sampling location		Type of sample *	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average *	12-month average	Monthly average *	12-month average
UNITED STATES:						
Ala:	Montgomery *	P	NA	5	13	4
Alaska:	Palmer *	P	6	4	0	1
Ariz:	Phoenix *	P	NA	0	0	0
Ark:	Little Rock *	P	15	10	0	2
Calif:	Sacramento *	P	NA	1	0	0
	San Francisco *	P	NA	0	0	0
	Del Norte	P	15	11	0	7
	Fresno	P	0	1	0	2
	Humboldt	P	3	3	0	2
	Los Angeles	P	0	1	0	2
	Mendocino	P	3	2	0	4
	Sacramento	P	2	2	12	3
	San Diego	P	0	1	0	3
	Santa Clara	P	0	2	0	2
	Shasta	P	2	2	0	4
	Sonoma	P	2	2	0	2
Colo:	Denver *	P	3	3	0 (2)	0
	East	R	NA		NA	
	Northeast	R	NA		NA	
	Northwest	R	NA		NA	
	South Central	R	NA		NA	
	Southeast	R	NA		NA	
	Southwest	R	NA		NA	
	West	R	NA		NA	
Conn:	Hartford *	P	NA	5	15	5
	Central	P	7	6	3	10
Del:	Wilmington *	P	NA	7	14	6
D.C:	Washington *	P	NA	5	0	3
Fla:	Tampa *	P	3	4	30	31
	Central	R	4	5	29	36
	North	R	6	6	0	13
	Northeast	R	4	5	26	32
	Southeast	R	5	5	82	45
	Tampa Bay area	P	4	5	25	31
	West	R	6	8	0	7
Ga:	Atlanta *	P	NS	8	NS	8
Hawaii:	Honolulu *	P	0	1	0	0
Idaho:	Idaho Falls *	P	5	3	0	0
Ill:	Chicago *	P	6	4	0	3
Ind:	Indianapolis *	P	NA	4	12	2
	Central	P	7	7	10	7
	Northeast	P	5	5	0	7
	Northwest	P	7	7	0	9
	Southeast	P	7	7	10	6
	Southwest	P	8	7	15	9
Iowa:	Des Moines *	P	NA	5	0	0
	Iowa City	P	5	6	0	2
	Des Moines	P	6	5	0 (3)	1
	Le Mars	P	4	4	0	2
	Little Cedar	P	NA	6	0	3
Kans:	Wichita *	P	NA	5	0	0
	Coffeyville	P	6	8	0	9
	Dodge City	P	3	4	0	5
	Falls City, Nebr	P	NS	—	NS	—
	Hays	P	5	9	0	6
	Kansas City	P	7	8	0	8
	Topeka	P	8	7	0	5
	Wichita	P	6	8	0	10
Ky:	Louisville *	P	NA	6	0	1
La:	New Orleans *	P	0	10	0	1
Maine:	Portland *	P	NA	5	24	19
Md:	Baltimore *	P	NA	6	13	5
Mass:	Boston *	P	9	7	14	15
Mich:	Detroit *	P	NA	6	0	3
	Grand Rapids *	P	NA	7	12	1
	Bay City	P	10	6	0	0
	Charlevoix	P	13	6	2 (5)	4
	Detroit	P	10	4	0	1
	Grand Rapids	P	10	5	0	2
	Lansing	P	11	6	0 (2)	3
	Marquette	P	14 (5)	5	12 (2)	10
	Monroe	P	14	4	0	0
	South Haven	P	18	7	3 (4)	4
Minn:	Minneapolis *	P	NA	7	12	8
	Bemidji	P	5	6	0	14
	Duluth	P	20	16	18	21
	Fergus Falls	P	7	7	8	12
	Little Falls	P	15	17	23	33
	Mankato	P	0	4	0	0
	Marshall	P	3	4	0	0

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for June 1973 and 12-month period July 1972 through June 1973—continued

Sampling location		Type of sample •	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average •	12-month average	Monthly average •	12-month average
Minn:	Minneapolis	P	11	9	0	12
	Rochester	P	7	7	0	0
Miss:	Jackson •	P	NA	8	19	7
Mo:	Kansas City •	P	NA	5	0	0
	St. Louis •	P	NA	6	0	1
Mont:	Helena •	P	NA	4	0	0
Nebr:	Omaha •	P	NA	4	0	0
Nev:	Las Vegas •	P	NA	1	0	0
N.H:	Manchester •	P	NA	6	19	12
N.J:	Trenton •	P	NA	6	13	6
N. Mex:	Albuquerque •	P	NA	0	0	0
N.Y:	Buffalo •	P	4	4	0	3
	New York City •	P	NA	8	15	4
	Syracuse •	P	NA	6	0	1
	Albany	P	5 (3)	4	0 (3)	0
	Buffalo	P	7	4	10	0
	Massena	P	8	5	23	0
	New York City	P	8	6	0	0
	Syracuse	P	NS	5	NS	0
N.C:	Charlotte •	P	NA	7	11	6
N. Dak:	Minot •	P	NA	8	0	1
Ohio:	Cincinnati •	P	NA	5	0	2
	Cleveland •	P	NA	6	13	3
Okla:	Oklahoma City •	P	NA	4	0	0
Oreg:	Portland •	P	6	4	0	2
	Baker	P	NA		NA	
	Coos Bay	P	NA		NA	
	Eugene	P	NA		NA	
	Medford	P	NA		NA	
	Portland composite	P	NA		NA	
	Portland local	P	NA		NA	
	Redmond	P	NA		NA	
	Tillamook	P	NA		NA	
Pa:	Philadelphia •	P	NA	6	11	2
	Pittsburgh •	P	NA	8	14	6
	Dauphin	P	3	5	0	2
	Erie	P	5	7	0	3
	Philadelphia	P	3	4	0	3
	Pittsburgh	P	7	6	0	4
R.I:	Providence •	P	NA	5	0	8
S.C:	Charleston •	P	5	7	17	8
	Chapin	R	NS	8	NS	11
	Clemson	R	8	7	12	5
	Columbia	R	8	7	9	10
	Fairfield	R	NS	7	NS	13
	Hartsville–02	R	NS	6	NS	15
	Hartsville–03	R	NS	18	NS	18
	Lee County	R	NS	8	NS	18
	Oconee County	R	NS	8	NS	7
	Pickens	R	NS	7	NS	4
	Williston	R	7	7	14	15
	Winnsboro	R	NS	8	NS	24
S. Dak:	Rapid City •	P	NA	5	0	0
Tenn:	Chattanooga •	P	NA	8	12	6
	Memphis •	P	NA	6	12	2
	Chattanooga	P	NA	8	16	7
	Clinton	R	NA	7	0 (2)	7
	Fayetteville	R	NA	8	0 (2)	5
	Kingston	R	NA	7	0 (2)	1
	Knoxville	R	NA	6	0 (2)	3
	Lawrenceburg	R	NS	6	NS	8
	Nashville	R	NS	7	NS	2
	Pulaski	R	NA	6	0 (2)	3
	Sequoyah	R	NS	7	NS	6
Tex:	Austin •	P	NA	2	0	0
	Dallas •	P	NA	5	0	0
	Amarillo	R	NA		NA	
	Corpus Christi	R	NA		NA	
	El Paso	R	NA		NA	
	Fort Worth	R	NA		NA	
	Harlingen	R	NA		NA	
	Houston	R	NA		NA	
	Lubbock	R	NA		NA	
	Midland	R	NA		NA	
	San Antonio	R	NA		NA	
	Texarkana	R	NA		NA	
	Uvalde	R	NA		NA	
	Wichita Falls	P	NA		NA	
Utah:	Salt Lake City •	P	3	3	0	2
Vt:	Burlington •	P	NA	5	13	8
Va:	Norfolk •	P	NA	6	11	3
Wash:	Seattle •	P	NA	4	0	1
	Spokane	P	NA	4	0	1

See footnotes at end of table.

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Table 2. Concentrations of radionuclides in milk for June 1973 and 12-month period July 1972 through June 1973—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
Wash:	Benton County	R	NS	1	NS	0
	Franklin County	R	0	1	0	0
	Longview	R	5	3	[illegible]	3
	Sandpoint, Idaho	R	6	6	0	3
	Skagit County	R	5	6	0	3
W. Va:	Charleston [c]	P	NA	7	17	5
Wisc:	Milwaukee [c]	P	NA	5	0	2
Wyo:	Laramie [c]	P	NA	2	0	0
CANADA:						
Alberta:	Calgary	P	5	5	9	10
	Edmonton	P	5	6	11	15
British Columbia:						
	Vancouver	P	8	7	16	15
Manitoba:						
	Winnipeg	P	4	5	13	12
New Brunswick:						
	Moncton	P	8	7	12	9
Newfoundland:						
	St. John's	P	11	16	17	21
Nova Scotia:						
	Halifax	P	6	7	9	12
Ontario:	Ottawa	P	5	6	5	7
	Sault Ste. Marie	P	10	10	16	18
	Thunder Bay	P	8	9	NS	18
	Toronto	P	4	3	5	7
	Windsor	P	2	3	3	7
Quebec:	Montreal	P	5	5	7	8
	Quebec	P	8	8	NS	8
Saskatchewan:						
	Regina	P	5	5	5	9
	Saskatoon	P	5	6	7	9
CENTRAL AND SOUTH AMERICA:						
Canal Zone:						
	Cristobal [c]	P	NA	1	0	12
Chile:	Santiago	P	0	1	0	1
Colombia:	Bogota	P	0	0	0	0
Ecuador:	Guayaquil	P	0	0	0	0
Jamaica:	Montego Bay	P	NS	2	NS	39
Puerto Rico:						
	San Juan [c]	P	NA	1	11	2
Venezuela:	Caracas	P	3	1	0	2
PMN network average [e]			5	5	6	4

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a month period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] The practical reporting level for this network differs from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:
Cesium-137: Colorado—25 pCi/liter; Oregon—15 pCi/liter.

[e] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average

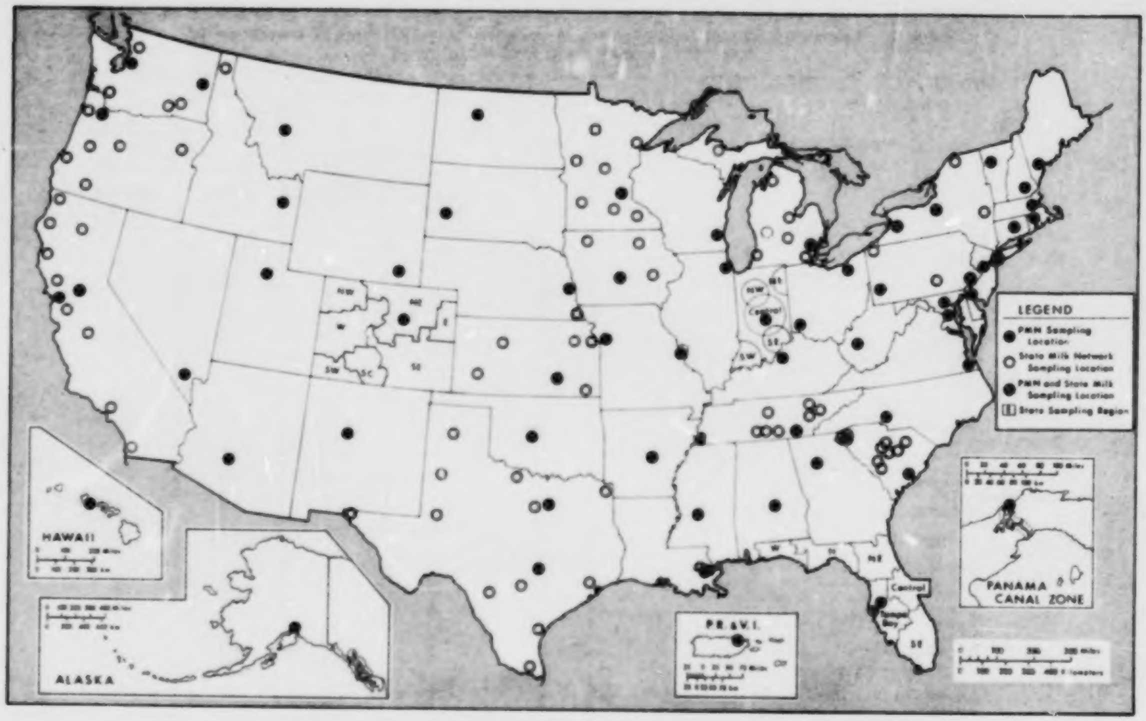
LEGEND
PMN Sampling Location
State Milk Network Sampling Location
PMN and State Milk Sampling Location
State Sampling Region
HAWAII
ALASKA
P.R. & V.I.
PANAMA CANAL ZONE
NW
NE
E
W
SW
SC
SE
Central
Tampa Bay

Figure 2. State and PMN sampling stations in the United States

for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for June 1973 and the 12-month period, July 1972 to June 1973. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from table 2 since levels at all of the stations for June 1973 were below the respective practical reporting levels.

Strontium-90 monthly averages ranged from 0 to 20 pCi/liter in the United States for June 1973 and the highest 12-month average was 18 pCi/liter (Hartsville-03, S.C.) representing 9.0 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 82 pCi/liter in the United States for June 1973, and the highest 12-month average was 45 pCi/liter (Southeast Florida) representing 1.3 percent of the value derived from the recommendations given in the Federal Radiation Council report.

Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data from their milk surveillance networks:

Environmental Control Component
Radiologic Health Section
California Department of Health

Radiation Protection Division
Canadian Department of National
Health and Welfare

Radiological Health Section
Division of Occupational and
Radiological Health
Colorado Department of Health

Laboratory Division
Connecticut Department of Health

Radiological and Occupational
Health Section
Department of Health and
Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of
Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Division of Radiological Health
South Carolina State Board of Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of
Social and Health Services

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(*2*) U.S. ATOMIC ENERGY COMMISSION, DIVISION OF ISOTOPES DEVELOPMENT. Chart of the Nuclides, Tenth Edition revised to December 1968. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*3*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk Surveillance. Radiol Health Data Rep 9:730–746 (December 1968).

(*4*) ROSENSTEIN, M. and A. S. GOLDIN. Statistical technics for quality control of environmental radioassay. Health Lab Sci 2:93 (April 1965).

(*5*) BARATTA, E. J. and F. E. KNOWLES, JR. Interlaboratory study of iodine-131, cesium-137, strontium-89, and strontium-90 measurements in milk, June 1972, Technical experiment 72 MKAQ-1. Analytical Quality Control Service, Office of Radiation Programs, EPA, Washington, D.C. 20460 (December 1972).

(*6*) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).

Milk Surveillance Network, April-May 1973

National Environmental Research Center—
Las Vegas, Environmental Protection Agency

The Milk Surveillance Network,[1] operated by the National Environmental Research Center—Las Vegas (NERC-LV) consists of 24 routine and two alternate sampling locations (figure 1) situated in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing conducted by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site.

In the event of a release of radioactivity from the NTS, special sampling within the affected

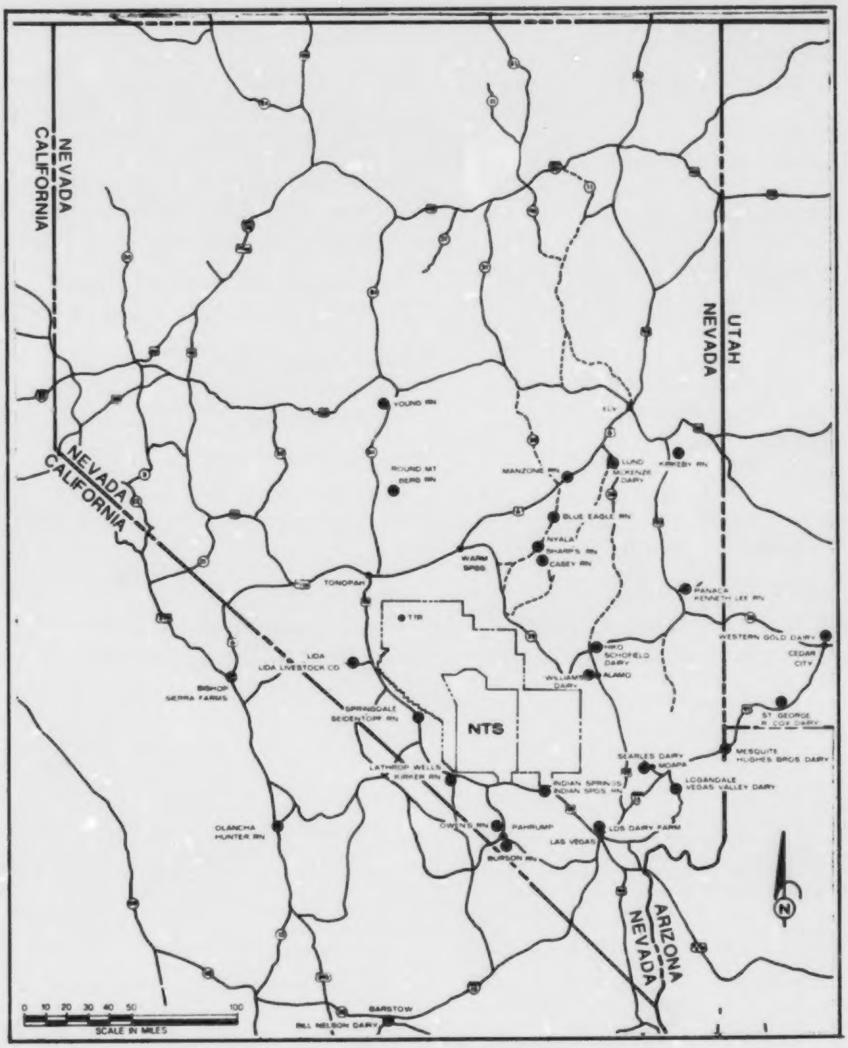
NEVADA
CALIFORNIA
UTAH
NEVADA
YOUNG RN
ROUND MT
BERG RN
ELY
MANZONE RN
LUND
MCKENZIE
DAIRY
KIRKEBY RN
BLUE EAGLE RN
NYALA
SHARP'S RN
CASEY RN
WARM SPGS
TONOPAH
PANACA
KENNETH LEE RN
TTR
WESTERN GOLD DAIRY
CEDAR CITY
HIKO
SCHOFELD
DAIRY
WILLIAMS DAIRY
ALAMO
LIDA
LIDA LIVESTOCK CO
BISHOP
SIERRA FARMS
SPRINGDALE
SEIDENTOPP RN
NTS
ST GEORGE
R. COX DAIRY
MESQUITE
HUGHES BROS DAIRY
SEARLES DAIRY
MOAPA
LATHROP WELLS
KIRKER RN
INDIAN SPRINGS
INDIAN SPGS RN
LOGANDALE
VEGAS VALLEY DAIRY
OLANCHA
HUNTER RN
OWENS RN
PAHRUMP
LOS DAIRY FARM
LAS VEGAS
BURSON RN
ARIZONA
NEVADA
N
0 10 20 30 40 50 100
SCALE IN MILES
BARSTOW
BILL NELSON DAIRY

Figure 1. NERC-LV Milk Surveillance Network

area is conducted to determine radionuclide concentrations. Additional milk sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and analytical procedures was included with the milk results reported in the July 1973 issue of *Radiation Data and Reports.*

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[1] This network is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. AEC, Las Vegas, Nev.

Results

The analytical results of all milk samples collected in April and May 1973 by NERC-LV surveillance programs are listed in tables 1 and 2. With the exception of cesium-137 at levels near the minimum detectable activity (MDA) of 10 pCi/liter, no gamma-emitting fission products were identified by gamma spectrometry in any of the samples collected during April and

Table 1. Milk surveillance results, April 1973

Location	Date collected (1973)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)			
			Cesium-137	Strontium-89	Strontium-90	Tritium
California:						
Bishop: Sierra Farms	4/11	11	<10	<2.0	<1.2	NA
Hinkley: Bill Nelson Dairy	4/9	12	<10	<2.0	<1.0	NA
Olancha: Hunter Ranch	4/10	13	<10	<2.0	<1.0	NA
Nevada:						
Alamo: Williams Dairy	4/10	12	<10	<2.0	<1.2	NA
Austin: Young's Ranch	4/9	13	<10	<2.0	2.3±1.3	630±250
Currant: Blue Eagle Ranch	4/16	13	10	<3.0	2.4±1.6	NA
Manzonie Ranch	4/17	13	<10	<3.0	2.1±1.7	NA
Hiko: Schofield Dairy	4/10	12	<10	<2.0	<1.1	<250
Indian Springs: Indian Springs Ranch	NS					
Las Vegas: LDS Dairy Farms	4/13	12	<10	<1.0	<.9	<250
Lathrop Wells: Kirker Ranch	4/11	13	<10	<2.0	<1.2	NA
Lida: Lida Livestock Company	4/9	13	<10	<2.0	<1.0	NA
Logandale: Vegas Valley Dairy	4/9	12	<10	<2.0	<1.1	NA
Lund: McKenzie Dairy	4/16	12	<10	<3.0	1.7±1.6	<240
Mesquite: Hughes Bros. Dairy	4/10	12	13	<2.0	1.9±1.2	<250
Moapa: Searles Diary	4/10	12	<10	<2.0	2.0±1.4	NA
Nyala: Sharp's Ranch	4/11	13	<100	<2.0	<1.0	<250
Pahrump: Owens Ranch	4/11	13	<10	<1.0	<.9	NA
Panaca: Kenneth Lee Ranch	NS					
Round Mountain: Berg Ranch	4/9	13	<10	<3.0	3.8±1.8	NA
Shoshone: Kirkeby Ranch	4/15	13	<10	<2.0	<1.3	NA
Springdale: Seidentopf Ranch	4/10	13	<10	<2.0	<1.1	NA
Utah:						
Cedar City: Western Gold Dairy	4/10	12	<10	<2.0	1.7±1.2	NA
St. George: R. Cox Dairy	4/11	12	<10	<2.0	<1.1	NA

[a] 11—Pasteurized milk.
12—Raw milk from Grade A producer(s).
13—Raw milk from family cow(s).
[b] Two-sigma counting error provided when available.
[c] Small sample size increased MDA.
NA, no analysis.
NS, no sample.

May. Levels of tritium near the MDA for this radionuclide (200 pCi/liter) were also measured by liquid scintillation counting technique. The highest concentration of tritium during April was 630 ± 260 pCi/liter while all concentrations during May were <240 pCi/liter.

Table 2. Milk surveillance results, May 1973

Location	Date collected (1973)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)			
			Cesium-137	Strontium-89	Strontium-90	Tritium
California:						
Bishop:						
Sierra Farms	5/1	11	<10	NA	NA	NA
Hinkley:						
Bill Nelson Dairy	5/1	12	<10	NA	NA	NA
Olancha:						
Hunter Ranch	5/3	13	<10	NA	NA	NA
Nevada:						
Alamo:						
Williams Dairy	5/1	12	<10	NA	NA	NA
Austin:						
Young's Ranch	NS					
Currant:						
Blue Eagle Ranch	5/7	13	[c] <100	NA	NA	NA
Manzonie Ranch	5/8	13	<10	NA	NA	NA
Hiko:						
Schofield Dairy	5/1	12	<10	NA	NA	<240
Indian Springs:						
Indian Springs Ranch	NS					
Las Vegas:						
LDS Dairy Farms	5/3	12	<10	NA	NA	<230
Lathrop Wells:						
Kirker Ranch	5/9	13	<10	NA	NA	NA
Lida:						
Lida Livestock Company	5/1	13	<10	NA	NA	NA
Logandale:						
Vegas Valley Dairy	5/1	12	<10	NA	NA	NA
Lund:						
McKenzie Dairy	5/8	12	<10	NA	NA	<230
Mesquite:						
Hughes Bros. Dairy	5/1	12	<10	NA	NA	<230
Moapa:						
Searles Dairy:	5/1	12	12	NA	NA	NA
Nyala:						
Sharp's Ranch	5/2	13	[c] <100	NA	NA	<240
Pahrump:						
Owens Ranch	5/8	13	<10	NA	NA	NA
Panaca:						
Owens Ranch	NS					
Round Mountain:						
Berg Ranch	5/1	13	<10	NA	NA	NA
Shoshone:						
Kirkeby Ranch	5/9	13	<10	NA	NA	NA
Springdale:						
Seidentopf Ranch	5/9	13	<10	NA	NA	NA
Utah:						
Cedar City:						
Western Gold Dairy	5/1	12	<10	NA	NA	NA
St. George:						
R. Cox Dairy	5/2	12	<10	NA	NA	NA

[a] 11—Pasteurized milk.
12—Raw milk from Grade A producer(s).
13—Raw milk from family cow(s).

[b] Two-sigma counting error provided when available.

[c] Small sample size increased minimum detectable activity.
NA, no analysis.
NS, no sample.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intake of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	January–June 1971	December 1972
Carbon-14 in Total Diet and Milk	July–December 1971	May 1972
Institutional Diet	October–December 1972 and 1972 Annual Summary	September 1973
Radiostrontium in Milk	1971	November 1972
Strontium-90 in Tri-City Diets	1971	December 1972

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	1970	June 1972
Colorado River Basin	1968	March 1972
Community Water Supply Study	1968	September 1972
Florida	1969	January 1972
Interstate Carrier Drinking Water	1971	May 1972
Kansas	1971	February 1973
Michigan	January–June 1970	November 1971
Minnesota	July 1970–June 1971	November 1972
New York	July–December 1971	August 1973
North Carolina	1968–1970	September 1972
Radiostrontium in Tap Water, *HASL*	July–December 1971	November 1972
Tritium Surveillance	January–March 1973	July 1973
Washington	July 1970–June 1971	August 1973
Water Surveillance Programs, *NERC-LV*	March 1973	September 1973

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(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies, Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

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Tritium Surveillance System, April-June 1973

Office of Radiation Programs
Environmental Protection Agency

The Tritium Surveillance System is an expansion of previous tritium surveillance activities initiated by the Public Health Service and transferred in 1970 to the Office of Radiation Programs, Environmental Protection Agency (EPA). The principal effort in the past related to tritium releases was the Tritium in Surface Water Network. This network was established in 1964 to measure and monitor tritium concentrations in major river systems in the United States and to provide surveillance at surface water stations downstream from selected nuclear facilities. The network consisted of selected stations from the existing water pollution surveillance sampling stations. The final data from this network for January–June 1970, have been published previously (*1*).

Another sampling program of the Public Health Service was a tritium in precipitation program. This project was established in 1967 at selected Radiation Alert Network (RAN) stations covering the United States, including Alaska and Hawaii. The RAN is now operated by the Office of Air Programs of the EPA. The data from this project for July–December 1969 have been published previously (*2*). Due to the increased interest in tritium releases from nuclear facilities and the potential long-term accumulation in the environment, a national system was established to incorporate these projects or networks into one overall system.

Present network

The Tritium Surveillance System consists of 68 quarterly drinking water samples at the RAN stations, precipitation samples collected daily and analyzed monthly from 8 of the RAN stations (figure 1), and quarterly samples at

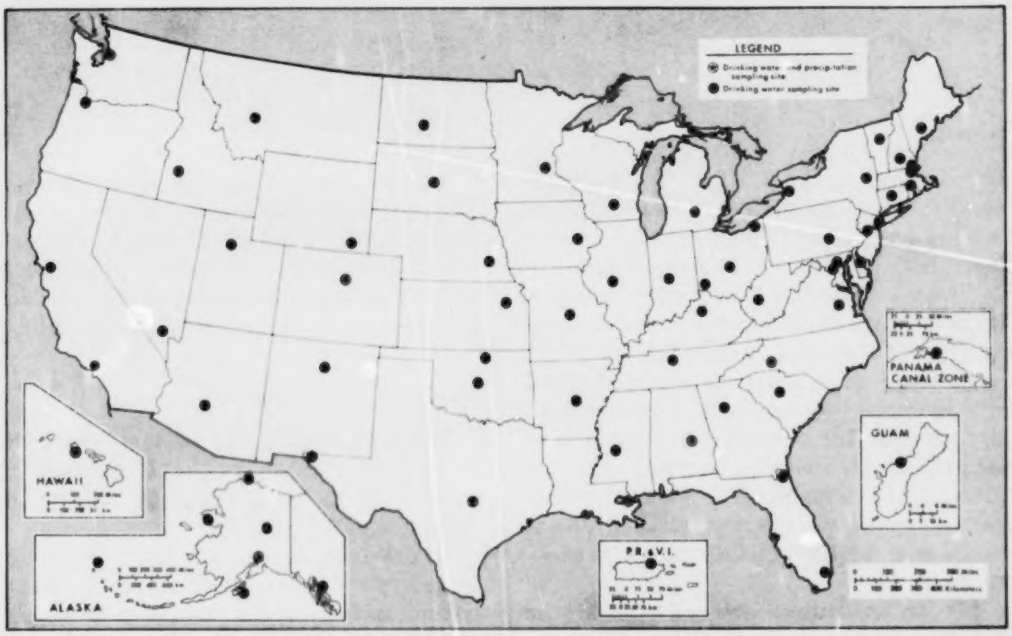
LEGEND
Drinking water and precipitation sampling site
Drinking water sampling site
HAWAII
ALASKA
P.R. & V.I.
PANAMA CANAL ZONE
GUAM

Figure 1. Drinking water and precipitation sampling locations for tritium surveillance system

30

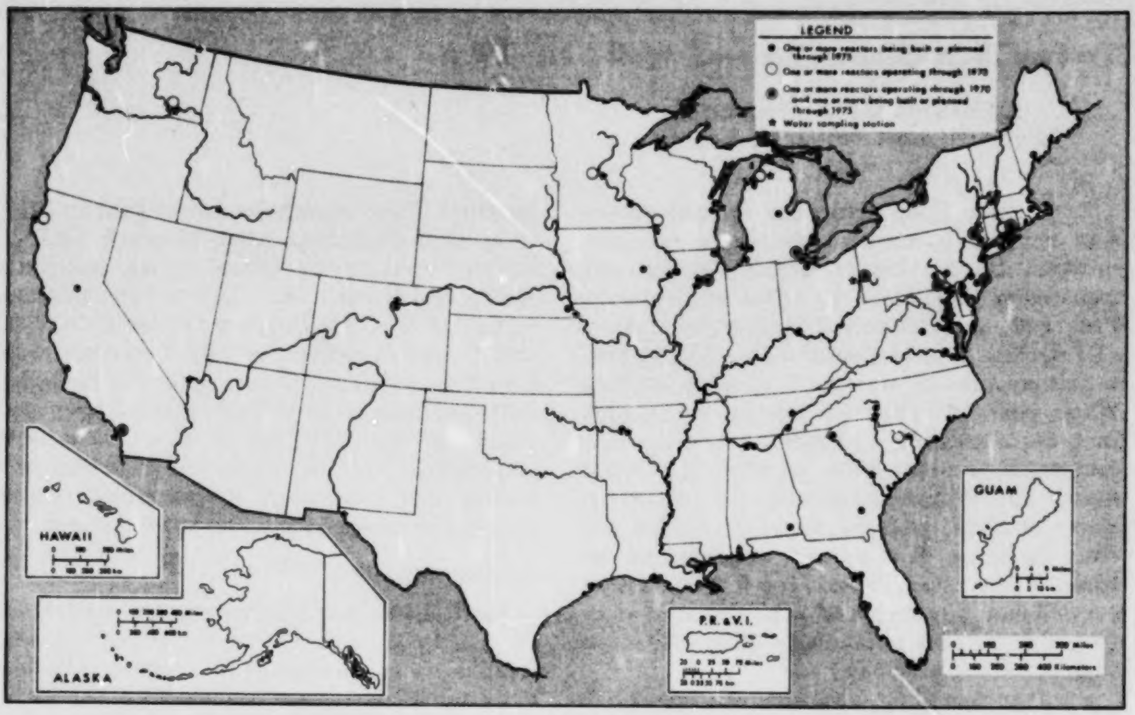
LEGEND
● One or more reactors being built or planned through 1975
○ One or more reactors operating through 1970
● One or more reactors operating through 1970 and one or more being built or planned through 1975
★ Water sampling station
HAWAII
ALASKA
P.R. & V.I.
GUAM

Figure 2. Surface water sampling locations for tritium surveillance system

39 surface water stations (figure 2). The specific locations for the surface water sampling system were determined by examining the water drainage areas to assure that a representative sample from a large area or region was obtained, and if possible, incorporating several nuclear facility sites. All nuclear facilities that were operating, being constructed, or planned through 1975 were considered. Consideration was also given to the current surveillance programs of the States that will be involved in the collection of the samples. The surface water samples are collected quarterly either downstream from a nuclear facility or at a background station.

The tap water samples are collected by the RAN operators on a quarterly basis. The precipitation samples are also collected by the RAN operators on a daily basis.

All samples are sent to either the Eastern Environmental Radiation Facility or the National Environmental Research Center—Las Vegas, for analysis. Analytical values which are not statistically significant at the 2-sigma confidence level have been reported as zero.

Results and discussion

Table 1 presents the tritium concentrations in drinking water at the RAN stations for April–June 1973. The average tritium concentration was 0.2 nCi/liter.

In previous articles on the Tritium Surveillance System, the reported dose equivalents from tritium in body water have been based on a relationship derived by Moghissi and Porter (*3*). Their relationship assumed a quality factor of 1.7 for tritium beta rays based on a 1966 ICRP recommendation (*4*). Recently, the NCRP has recommended a quality factor of 1 for tritium beta rays (*5*) and this recommendation has been adopted for this and subsequent reports.

Table 1. Tritium concentration in tap-water (RAN stations), April-June 1973

Location		Date collected (1973)	Tritium concentration[a] (nCi/liter ± 2σ)[b]
Ala:	Montgomery	4/2	0.0
Alaska:	Anchorage	4/2	.5 ± 0.3
	Attu Island	4/2	0 ± .3
	Fairbanks	4/7	.5 ± .3
	Juneau	4/5	0 ± .3
	Nome	4/16	.5 ± .3
	Point Barrow	4/2	.4 ± .3
Ariz:	Phoenix	4/23	.3
Ark:	Little Rock	4/2	0 ± .3
Calif:	Berkeley	4/4	0 ± .3
	Los Angeles	4/2	0 ± .3
C.Z:	Ancon	4/16	0
Colo:	Denver	4/16	.8 ± .3
Conn:	Hartford	4/4	0
Del:	Dover	4/6	0
D.C:	Washington	4/2	.2
Fla:	Jacksonville	4/2	0
	Miami	4/2	0
Ga:	Atlanta	4/11	.2
Guam:	Agana	4/2	0 ± .3
Hawaii:	Honolulu	4/5	0 ± .3
Idaho:	Boise	4/3	0 ± .3
Ill:	Springfield	4/3	.3
Ind:	Indianapolis	4/3	.2
Iowa:	Iowa City	4/2	0 ± .3
Kans:	Topeka	4/10	0 ± .3
Ky:	Frankfort	4/5	0
La:	New Orleans	4/10	.3 ± .3
Maine:	Augusta	4/3	0
Md:	Baltimore	4/2	.2
Mass:	Lawrence	4/2	0
	Winchester	4/3	.2
Mich:	Lansing	4/3	0
Minn:	Minneapolis	4/9	.3
Miss:	Jackson	4/2	0
Mo:	Jefferson City	4/3	0 ± .3
Mont:	Helena	4/2	0 ± .3
Nebr:	Lincoln	4/2	0 ± .3
Nev:	Las Vegas	4/3	.6 ± .3
N.H:	Concord	4/2	.3
N.J:	Trenton	4/3	0
N. Mex:	Sante Fe	4/3	0 ± .3
N.Y:	Albany	4/4	0
	Buffalo	4/3	.3
	New York City	4/6	0
N.C:	Gastonia	4/2	.2
N. Dak:	Bismarck	5/1	1.0 ± .3
Ohio:	Cincinnati	4/6	.4
	Columbus	4/3	0
	Painesville	4/2	.4
Okla:	Oklahoma City	4/11	0
Oreg:	Portland	4/2	0 ± .3
Pa:	Harrisburg	4/12	0
P.R:	San Juan	4/3	0
R.I:	Providence	4/6	0
S.C:	Columbia	4/2	.2
S. Dak:	Pierre	4/2	.5 ± .3
Tenn:	Nashville	4/2	0
Tex:	Austin	4/5	0 ± .3
	El Paso	4/3	0 ± .3
Utah:	Salt Lake City	4/2	0 ± .3
Vt:	Barre	4/2	.2
Va:	Richmond	4/5	.2
Wash:	Seattle	4/11	0
	Spokane	4/2	0 ± .3
W. Va:	Charleston	4/2	.2
Wisc:	Madison	4/6	.2
Wyo:	Cheyenne	4/3	.9 ± .3
Average			0.2

[a] The minimum detection limit for all samples was 0.20 nCi/liter. All values equal to or less than 0.20 nCi/liter before rounding have been reported as zero.

[b] The 2σ error for all samples is 0.[illegible] nCi/liter unless otherwise noted.

Following the notation adopted by the ICRU (*6*), substitution of a quality factor of 1 in Moghissi and Porter calculations yields:

$$\dot{H}\ (\text{mrem/year}) = 0.1C\ (\text{nCi/liter})$$

Where $\dot{H}$ is the dose equivalent rate and C represents the tritium concentration in body water.

Assuming that the concentration of tritium in all water taken into the body is equal to that found in the drinking water and also that the specific activity of tritium in the body is essentially the same as that in the drinking water, then the radiation dose may be estimated.

The highest individual concentration of tritium observed in the drinking water was 1.0 nCi/liter during the second quarter. This corresponds to a dose of 0.1 mrem/a, or less than 0.06 percent of the Federal Radiation Council's Radiation Protection Guide (170 mrem/a) for an average dose to a suitable sample of the exposed population.

The tritium concentrations for the surface water samples are given in table 2. The highest tritium concentration was 2.8 nCi/liter for the second quarter. Assuming that the specific activity of tritium in the body is essentially the same as that in surface water, this concentration corresponds to a dose of 0.3 mrem/a, or 0.2 percent of the Radiation Protection Guide.

The monthly analyses for tritium in precipitation samples at the 8 RAN stations are shown in table 3.

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(*2*) BUREAU OF RADIOLOGICAL HEALTH. Tritium in precipitation (RAN), July–December 1969. Radiol Health Data Rep 11:354–355 (July 1970).

(*3*) MOGHISSI, A. A. and C. R. PORTER. Tritium in surface waters in the United States, 1966. Radiol Health Data Rep 9:337–339 (July 1968).

Table 2. Tritium concentration in surface water, April–June 1973

Location		Water source	Facility	Collection date (1973)	Concentration [a] (nCi/liter $\pm 2\sigma$)[b]
Ala:	Decatur	Tennessee River	Browns Ferry	4/3	0.3
Ark:	Morrilton	Arkansas River	Arkansas Nuclear	4/2	0 ±0.3
Calif:	Eureka	Humboldt Bay	Humboldt Bay	4/7	0 ± .3
	San Onofre	Pacific Ocean	San Onofre	4/10	0
Colo:	Greely	South Platte River	Fort St. Vrain	4/16	.7 ± .3
Conn:	East Haddam	Connecticut River	Connecticut Yankee & Vermont Yankee	4/24	1.9
	Waterford	Long Island Sound	Millstone	4/25	0
Fla:	Crystal River	Gulf of Mexico	Crystal River	4/17	0
	Homestead	Biscayne Bay	Turkey Point	4/12	0
Idaho:	Buhl	Snake River	National Reactor Testing Station	4/2	0 ± .3
Ill:	Moline	Mississippi River	Quad-Cities	4/30	.2
	Morris	Illinois River	Dresden and Argonne	4/6	.2
La:	New Orleans	Mississippi River	(Several)	4/2	0 ± .3
Md:	Conowingo	Susquehanna River	Peach Bottom and Three Mile Island	4/11	0
	Lusby	Chesapeake Bay	Calvert Cliffs	4/3	0
Mass:	Rowe	Deerfield River	Yankee	4/4	.5
Mich:	Charlevoix	Lake Michigan	Big Rock Point	4/5	.2
	Monroe	Lake Erie	Enrico Fermi	4/12	.3
	South Haven	Lake Michigan	Palisades	4/10	0
Minn:	Monticello	Mississippi River	Monticello	4/9	.4
Nebr:	Rulo	Missouri River	Fort Calhoun and Cooper	4/4	0 ± .3
Nev:	Boulder City	Colorado River	Background	4/3	.9 ± .3
N.J:	Bayside	Delaware River	Salem	4/27	.2
N.Y:	Ossining	Hudson River	Indian Point	4/4	.3
	Oswego	Lake Ontario	Nine Mile Point and R. E. Ginna	4/10	.4
	Poughkeepsie	Hudson River	Background	4/4	.2
N.C:	Charlotte	Catawba River	Wm. B. McGuire	4/5	0
Oreg:	Westport	Columbia River	Trojan and Hanford	NS	
S.C:	Allendale	Savannah River	Savannah River Plant and Oconee	[c]3/22	2.8
	Hartsville	Lake Robinson	H. B. Robinson	3/16	1.6
Tenn:	Kingston	Clinch River	Oak Ridge	4/10	2.3
Tex:	El Paso	Rio Grande	Los Alamos	4/2	0 ± .3
Vt:	Vernon	Connecticut River	Vermont Yankee	4/3	.2
Va:	Newport News	James River	Surry	[c]3/29	0
Wash:	Northport	Columbia River	Background	4/9	.4 ± .3
	Richland	Columbia River	Hanford	4/4	.5 ± .3
W. Va:	Wheeling	Ohio River	Shippingport	4/4	.2
Wisc:	Two Creeks	Lake Michigan	Point Beach and Kewaunee	4/16	0
	Victory	Mississippi River	LaCrosse and Prairie Island	4/12	.2
Average					0.4

[a] The minimum detection limit for all samples was 0.20 nCi/liter. All values equal to or less than 0.20 nCi/liter before rounding have been reported as zero.

[b] The 2σ error for all samples is 0.2 nCi/liter unless otherwise noted.

[c] Sample collected early.

NS, no sample.

Table 3. Tritium concentration in precipitation from RAN stations, April–June 1973

Location		Tritium concentration[a] (nCi/liter $\pm 2\sigma$)		
		April	May	June
Ala:	Montgomery	0.0	0.0	0.0
Alaska:	Anchorage	[b].2	[b].2	[b].2
Colo:	Denver	.6	.6	0
Hawaii:	Honolulu	0	0	0
La:	New Orleans	0	0	0
N.C:	Gastonia	.9	.3	.7
Tex:	Austin	0	.2	0
Wash:	Seattle	.2	.2	0

[a] The minimum detection limit for these samples was 0.20 nCi/liter. All values equal to or less than 0.20 nCi/liter before rounding have been reported as zero. The 2σ error for all samples is 0.2 nCi/liter unless otherwise noted.

[b] Composite sample for March-June 1973.

(4) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Recommendations of the International Commission on Radiological Protection (Adopted September 17, 1965), ICRP Publication 9 (1969).

(5) NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS. Basic Radiation Protection Criteria, NCRP Report No. 39, National Council on Radiation Protection and Measurements, Washington, D.C. 20008 (January 15, 1971).

(6) INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS, Radiation Quantities and Units, ICRU Report No. 19, Washington, D.C. 20014 (July 1972).

Other coverage in *Radiation Data and Reports:*

Period	Issue
April–June 1972	January 1973
July–September 1972	February 1973
October–December 1972	May 1973
January–March 1973	July 1973

ater Surveillance Programs, April-May 1973

National Environmental Research Center—
Las Vegas, Environmental Protection Agency

The Water Surveillance Network,[1] operated by the National Environmental Research Center—Las Vegas (NERC-LV), consists of 61 sampling locations (figures 1 and 2) in the off-site area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing programs conducted by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site.

In the event of a release from the NTS, special sampling within the affected area is conducted to determine radionuclide concentrations. Additional water sampling networks are

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[1] This network is operated under a Memorandum of Understanding (No. AT-(26-1)-539) with the Nevada Operations Office, U.S. AEC, Las Vegas, Nev.

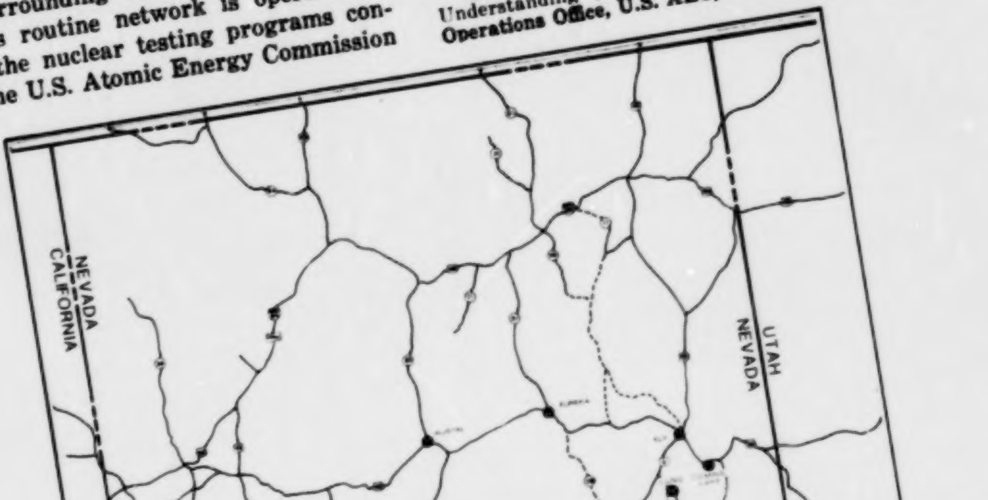
NEVADA
CALIFORNIA
UTAH
NEVADA
NEVADA
CALIFORNIA
NTS
ARIZONA
NEVADA
N
SAMPLING LOCATION
TWO SAMPLES AT SAME LOCATION SURFACE & CLOSED
0 10 20 30 40 50 100
SCALE IN MILES

Figure 1. NERC-LV Water Surveillance Network

Table 1. Water surveillance results, April 1973

Location	Date collected (1973)	Sample type [a]	Radioactivity concentrations [b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
California:					
Bishop:					
Fish and Game Office	4/11	23	<1.6	<3.0	NA
Death Valley Junction:					
Lila's Cafe	4/12	23	<5.2	<3.2	<250
Furnace Creek:					
Pond	4/12	21	<3.8	5.8±3.3	NA
Visitor Center	4/12	27	<3.3	<3.1	NA
Hinkley:					
Bill Nelson Dairy	4/9	23	5.9± 5.0	<3.1	NA
Lone Pine:					
Forest Service Ranger Station	4/10	23	<1.8	<3.0	NA
Olancha:					
Haiwee Reservoir	4/10	21	7.1± 4.0	<3.0	NA
Ridgecrest:					
City Hall	4/10	23	<3.0	<3.1	NA
Nevada:					
Adaven:					
Canfield Ranch	4/3	22	5.4± 3.6	<3.5	NA
Alamo:					
Pahranagat Lake	4/10	21	8.0± 5.6	6.5±3.1	NA
Sheri's Bar	4/10	23	<2.4	<3.4	NA
Williams Dairy	4/10	23	7.8± 4.8	9.5±3.9	NA
Ash Meadows:					
Ash Meadows Lodge	4/10	23	12 ± 7.8	12 ±3.8	<250
Pond	4/10	21	18 ± 9.6	17 ±4.2	NA
Austin:					
Nevada National Bank	4/9	27	24 ± 6.5	6.3±3.3	NA
Blue Diamond:					
Post Office	4/9	23	4.2± 3.9	<3.3	<250
Blue Jay Highway:					
Maintenance Station	4/10	23	<2.4	2.8±2.8	NA
Cactus Springs:					
Mobil Service Station	4/11	27	<2.4	<3.0	<250
Caliente:					
Agricultural Extension Station	4/12	23	4.5± 3.9	<2.8	NA
Clark Station:					
Five Mile Ranch	4/10	27	<1.9	4.2±2.9	NA
Currant:					
Currant Ranch Cafe	4/17	27	4.2± 3.6	<3.5	NA
Diablo:					
Highway Maintenance Station	4/11	23	<3.1	2.9±2.8	NA
Reed Ranch	4/9	21	15 ± 6.3	6.7±3.3	NA
Elgin:					
Water tower	4/12	23	5.6± 4.0	9.3±3.9	NA
Ely:					
Chevron Service Station	4/16	24	3.2± 2.6	<3.4	NA
Comins Lake	4/16	21	<2.3	6.8±3.6	NA
Eureka:					
Highway Maintenance Station	4/2	24	<2.8	<3.5	NA
Goldfield:					
Chevron Service Station	4/9	23	<3.1	<2.8	NA
Hiko:					
Crystal Springs	4/10	27	6.2± 4.2	3.6±2.8	NA
Schofield Dairy	4/10	23	21 ± 7.7	30 ±4.9	NA
Las Vegas:					
Craig Ranch Golf Course	4/9	23	<2.6	4.2±3.3	<250
Desert Game Range	4/9	23	4.3± 3.2	<3.3	<250
Lab II, NERC	4/9	24	5.4± 5.1	7.3±3.6	870±260
Lake Mead Vegas Wash	4/9	21	<4.0	6.3±3.6	750±270
Las Vegas Water District Well 28	4/9	23	<2.5	<3.3	<250
Municipal Golf Course	4/9	23	3.5± 3.0	3.4±3.3	<250
Twin Springs	4/9	23	<2.6	<3.3	<250
Twin Springs Pond	4/9	21	5.3± 3.4	<3.3	NA
Vegas Estates	4/9	23	<3.4	13 ±4.0	<260
Lida:					
Lida Livestock Company	4/9	27	2.9± 2.7	<3.4	NA
Pond at storage tank	4/9	21	<3.1	<2.8	NA
Lund:					
Gardner Grocery	4/17	23	3.0± 2.6	<3.4	NA
Manhattan:					
Country store	4/10	23	12 ± 6.2	<2.8	NA
Mesquite:					
Hughes Bros. Dairy	4/10	23	<3.6	3.1±2.9	NA
Moapa:					
Pedersen Valley View Ranch	4/10	27	<3.0	<3.0	NA
Mt. Charleston:					
Kyle Canyon Fire Station	4/9	27	<2.3	<3.3	<250
Nyala:					
Sharp's Ranch	4/11	23	<2.5	<2.8	NA
Pahrump:					
Texaco Service Station	4/11	23	<2.9	<3.0	NA
Pioche:					
County courthouse	4/11	24	2.3± 2.1	<3.4	NA
Round Mountain:					
Mobil Service Station	4/10	27	2.0± 1.8	<3.4	NA

See footnotes at end of table.

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Table 1. Water surveillance results, April 1973—continued

Location	Date collected (1973)	Sample type [a]	Radioactivity concentrations [b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
Scotty's Junction:					
Chevron Service Station	4/9	23	<5.0	3.5±2.9	340±240
Springdale:					
Pond	4/10	21	<4.4	6.3±3.4	NA
Sunnyside:					
Adam McGill Reservoir	4/17	21	8.5± 4.4	<3.4	NA
Wildlife Management Headquarters	4/17	27	<2.1	<3.4	NA
Tonopah:					
Jerry's Chevron Station	4/12	23	4.0± 2.9	4.5±3.5	NA
Tonopah Test Range CP-1	4/11	23	3.2± 3.0	6.9±3.7	NA
Warm Springs:					
Fallini's Pond	4/11	21	25 ±13	46 ±6.1	NA
Service Station and Cafe	4/10	27	35 ±12	28 ±4.5	NA
Twin Springs Ranch	4/11	23	<4.2	3.1±2.8	NA
Utah:					
Cedar City:					
M. D. Baldwin residence	4/11	24	<3.6	<3.1	NA
St. George:					
R. Cox Dairy	4/11	24	5.9± 3.1	<3.0	NA

[a] 21—Pond, lake, reservoir, stock tank, stock pond.
22—Stream, river, creek.
23—Well.
24—Multiple supply—mixed (A water sample consisting of mixed or multiple sources of water, such as well and spring.)
27—Spring.

[b] Two-sigma counting error provided when available.
NA, no analysis.

Table 2. Water surveillance results, May 1973

Location	Date collected (1973)	Sample type [a]	Radioactivity concentrations [b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
California:					
Bishop:					
Fish and Game Office	5/2	23	<0.7	<3.3	NA
Death Valley Junction:					
Lila's Cafe	5/3	23	<3.3	8.7±3.9	390±240
Furnace Creek:					
Pond	5/3	21	4.1± 3.9	11 ±3.9	NA
Visitor Center	5/3	27	<2.6	7.9±3.7	NA
Hinkley:					
Bill Nelson Dairy	5/1	23	4.3± 3.7	6.8±3.6	NA
Lone Pine:					
Forest Service Ranger Station	5/3	23	<1.4	<3.3	NA
Olancha:					
Haiwee Reservoir	5/2	21	8.9± 4.1	6.1±3.5	NA
Ridgecrest:					
City Hall	5/1	23	3.9± 3.4	<3.4	NA
Nevada:					
Adaven:					
Canfield Ranch	5/1	22	2.4± 2.3	<3.5	NA
Alamo:					
Pahranagat Lake	5/1	21	6.6± 4.6	11 ±4.1	NA
Sheri's Bar	5/1	23	5.2± 4.1	4.0±3.7	NA
Williams Dairy	5/1	23	4.9± 4.2	6.5±3.8	NA
Ash Meadows:					
Ash Meadows Lodge	NS				
Pond	NS				
Austin:					
Nevada National Bank	NS				
Blue Diamond:					
Post Office	5/1	23	<2.8	<3.5	<240
Blue Jay Highway:					
Maintenance Station	5/2	23	<2.6	<3.5	NA
Cactus Springs:					
Mobil Service Station	5/7	27	<1.3	<3.3	<240
Caliente:					
Agricultural Extension Station	5/2	23	5.4± 3.5	<3.6	NA
Clark Station:					
Five Mile Ranch	5/2	27	<2.4	5.8±3.6	NA
Currant:					
Currant Ranch Cafe	5/8	27	7.9± 4.5	5.6±3.5	NA

See footnotes at end of table.

Table 2. Water surveillance results, May 1973—continued

Location	Date collected (1973)	Sample type[a]	Radioactivity concentrations[b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
Diablo:					
Highway Maintenance Station	5/2	23	<2.6	7.8±3.8	NA
Reed Ranch	5/1	21	9.2± 5.0	14 ±4.1	NA
Elgin:					
Water tower	5/2	23	3.7± 3.2	<3.6	NA
Ely:					
Chevron Service Station	5/7	24	2.9± 2.3	3.4±3.3	NA
Comins Lake	5/7	21	8.5± 4.7	23 ±4.5	NA
Eureka:					
Highway Maintenance Station	5/1	24	2.9± 2.8	<3.5	NA
Goldfield:					
Chevron Service Station	5/1	23	<2.9	<3.6	NA
Hiko:					
Crystal Springs	5/1	27	5.5± 3.6	<3.6	NA
Schofield Dairy	5/1	23	24 ± 9.3	28 ±4.9	NA
Las Vegas:					
Craig Ranch Golf Course	5/1	23	3.5± 2.7	<3.5	<240
Desert Game Range	5/1	23	3.2± 2.5	<3.5	<240
Lab II, NERC	5/1	24	5.8± 4.6	6.0±3.8	800±250
Lake Mead Vegas Wash	5/1	21	4.9± 4.2	6.3±3.8	1000±250
Las Vegas Water District Well 28	5/22	23	<1.6	<3.3	<250
Municipal Golf Course	5/1	23	3.6± 2.6	<3.5	<240
Tule Springs	5/1	23	4.3± 2.8	<3.5	<240
Tule Springs Pond	5/1	21	3.1± 2.4	<3.5	NA
Vegas Estates	5/1	23	<3.5	6.4±3.8	<240
Lida:					
Lida Livestock Company	5/1	27	<2.6	<3.4	NA
Pond at storage tank	5/1	21	<1.6	<3.4	NA
Lund:					
Gardner Grocery	5/8	23	<2.2	<3.3	NA
Manhattan:					
Country store	5/1	23	15 ± 6.5	<3.7	NA
Mesquite:					
Hughes Bros. Dairy	5/1	23	3.8± 3.6	<3.6	NA
Moapa:					
Pedersen Valley View Ranch	5/1	27	4.1± 3.9	8.3±3.9	NA
Mt. Charleston:					
Kyle Canyon Fire Station	5/1	27	<2.2	<3.5	350±240
Nyala:					
Sharp's Ranch	5/2	23	<1.7	<3.5	NA
Pahrump:					
Texaco Service Station	5/7	23	2.5± 2.3	<3.3	NA
Pioche:[c]					
County courthouse	5/2	24	<2.5	<3.6	NA
Round Mountain:					
Mobil Service Station	5/1	27	<1.7	<3.3	NA
Scotty's Junction:					
Chevron Service Station	5/1	23	5.4± 4.6	6.9±3.9	280±240
Springdale:					
Pond	5/9	21	4.0± 3.7	7.7±3.7	NA
Sunnyside:					
Adam McGill Reservoir	5/8	21	7.5± 4.0	7.2±3.6	NA
Wildlife Management Headquarters	5/8	27	2.7± 2.3	<3.3	NA
Tonopah:					
Jerry's Chevron Station	5/1	23	<1.9	<3.6	NA
Tonopah Test Range CP-1	5/2	23	<2.6	<3.6	NA
Warm Springs:					
Fallini's Pond	5/2	21	25 ±11	52 ±6.4	NA
Service Station and Cafe	5/1	27	15 ± 7.5	27 ±5.0	NA
Twin Springs Ranch	5/1	23	4.6± 3.6	9.6±3.9	NA
Utah:					
Cedar City:					
M. D. Baldwin residence	5/2	24	<1.4	<3.5	NA
St. George:					
R. Cox Dairy	5/2	24	5.7± 2.7	<3.5	NA

[a] 21—Pond, lake, reservoir, stock tank, stock pond.
22—Stream, river, creek.
23—Well.
24—Multiple supply—mixed (A water sample consisting of mixed or multiple sources of water, such as well and spring.)
27—Spring.

[b] Two-sigma counting error provided when available.
NA, no analysis.
NS, no sample.

operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and routine analytical procedures was included with the water results reported in the July 1973 issue of *Radiation Data and Reports*.

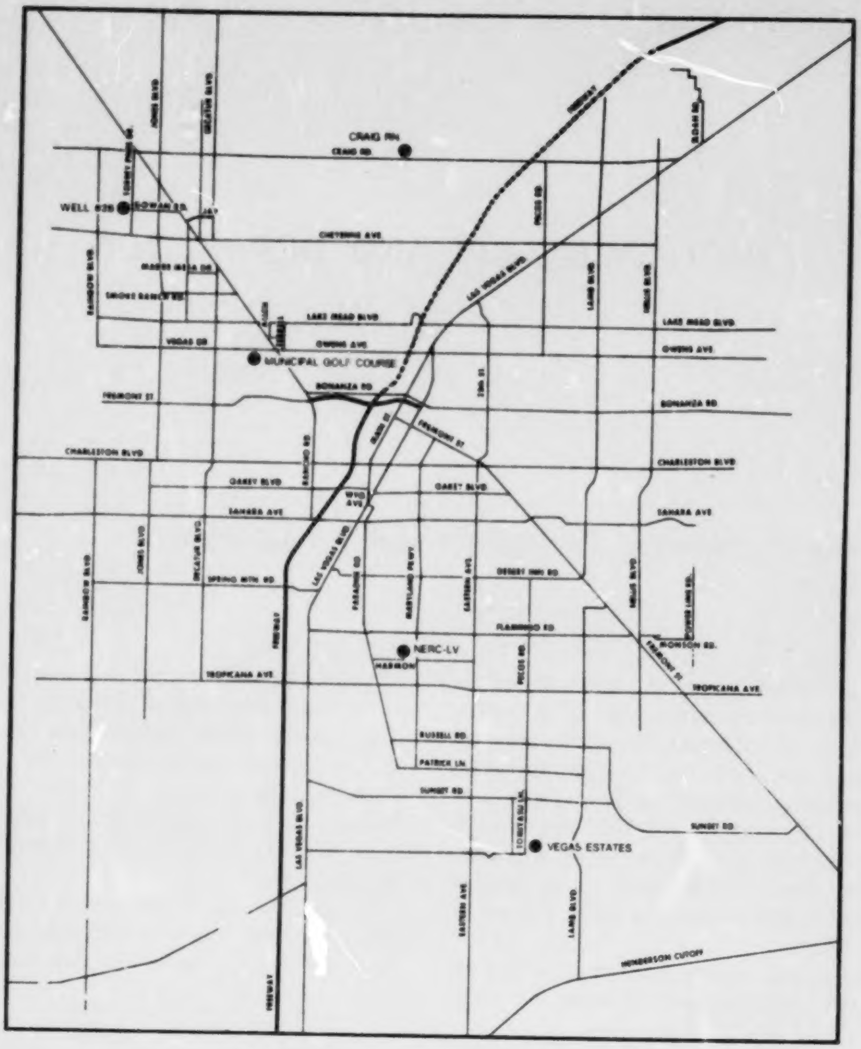
CRAIG RH
CRAIG RD
WELL #28
COWAN RD
CHEYENNE AVE
LAKE MEAD BLVD
OWENS AVE
VEGAS DR
MUNICIPAL GOLF COURSE
BONANZA RD
FREMONT ST
CHARLESTON BLVD
OAKEY BLVD
SAHARA AVE
SPRING MTN RD
DESERT INN RD
FLAMINGO RD
NERC-LV
HARMON
TROPICANA AVE
RUSSELL RD
PATRICK LN
SUNSET RD
VEGAS ESTATES
LAS VEGAS BLVD
EASTERN AVE
LAMB BLVD
RAINBOW BLVD
JONES BLVD
DECATUR BLVD
FREEWAY
HENDERSON CUTOFF
MONSON RD

Figure 2. NERC-LV Water Surveillance Network, Las Vegas Valley

Results

The routine analytical results of all water samples collected in April and May 1973 by the NERC-LV water surveillance network are listed in tables 1 and 2. No gamma-emitting fission products were identified by gamma spectrometry in any of the April and May samples. The analytical results for calendar year 1973 samples selected for special analyses will be reported at a later date.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Mexican National Institute of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiation Data and Reports.*

Network	Period	Issue
Plutonium in airborne particulates	October–December 1972	June 1973
Surface air sampling program, 80th Meridian Network, *HASL*	January–December 1971	September 1973
Fallout in the United States and other areas	1971	August 1973

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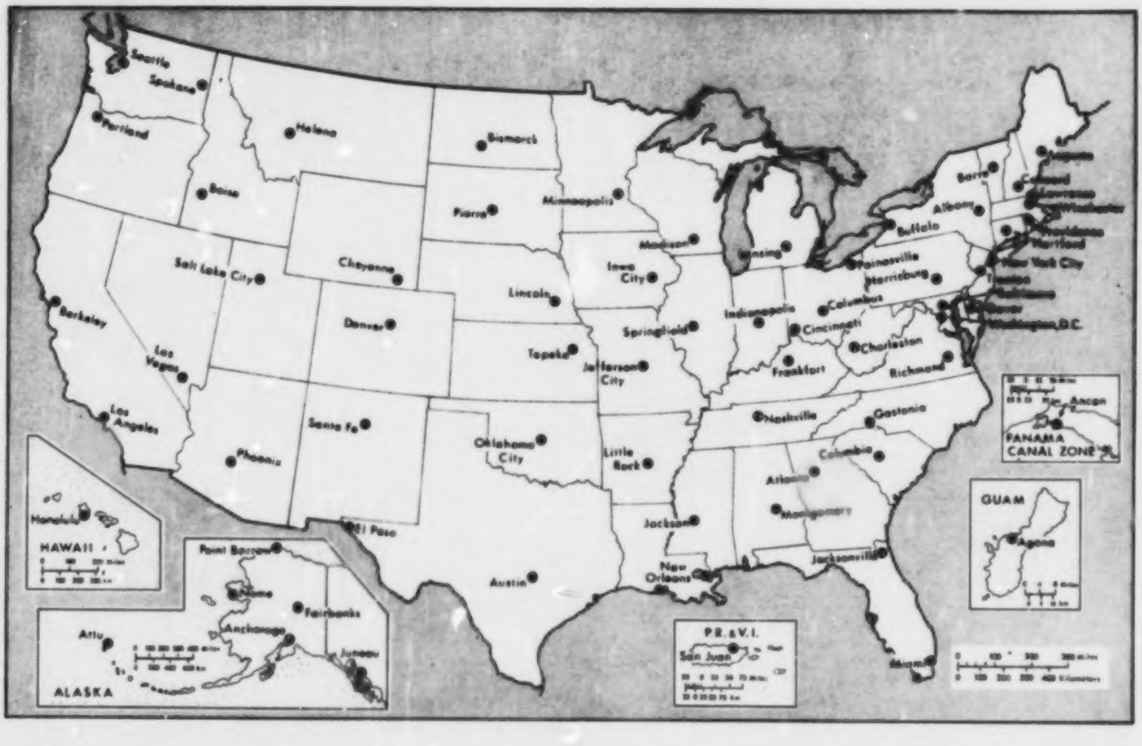
1. Radiation Alert Network
June 1973

Quality Assurance and Environmental Monitoring Laboratory, National Environmental Research Center—Research Triangle Park, Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 68 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Quality Assurance and Environmental Monitoring Laboratory, NERC-RTP, EPA, Research Triangle Park, N.C. 27711. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during June 1973.


Seattle
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Portland
Helena
Boise
Bismarck
Pierre
Minneapolis
Salt Lake City
Cheyenne
Lincoln
Denver
Berkeley
Las Vegas
Topeka
Los Angeles
Santa Fe
Phoenix
Oklahoma City
El Paso
Austin
Honolulu
HAWAII
Point Barrow
Nome
Fairbanks
Anchorage
Attu
Juneau
ALASKA
Madison
Iowa City
Lansing
Springfield
Jefferson City
Indianapolis
Columbus
Cincinnati
Frankfort
Charleston
Richmond
Buffalo
Painesville
Harrisburg
Albany
Barre
Augusta
New York City
Washington, D.C.
Nashville
Gastonia
Columbia
Atlanta
Montgomery
Little Rock
Jackson
New Orleans
Jacksonville
Miami
P.R. & V.I.
San Juan
Ancon
PANAMA CANAL ZONE
GUAM
Agana
0 100 200 300 Miles
0 100 200 300 400 Kilometers

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, June 1973

Station location	Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Precipitation				
		Maximum	Minimum	Average [a]	Number of samples	Total depth (mm)	Field estimation of deposition		
							Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala: Montgomery	15	2	0	1	4	82	4	82	12
Alaska: Anchorage	1	0	0	0	0				
Attu Island	29	1	0	0	0				
Fairbanks	0				0				
Juneau	0				0				
Nome	0				0				
Point Barrow	0				0				
Ariz: Phoenix	21	7	0	3	0				
Ark: Little Rock	0				0				
Calif: Berkeley	21	0	0	0	0				
Los Angeles	19	2	0	1	0				
C.Z: Ancon	14	0	0	0	0				
Colo: Denver	20	5	1	2	1	2	(b)		
Conn: Hartford	21	1	0	0	8	106	8	108	0
Del: Dover	20	1	0	0	0				
D.C: Washington	0				0				
Fla: Jacksonville	18	0	0	0	9	144	9	144	13
Miami	1	0	0	0	0				
Ga: Atlanta	0				0				
Guam: Agana	0				0				
Hawaii: Honolulu	20	1	0	0	2	7	(b)		
Idaho: Boise	15	1	0	1	1	10	1	10	0
Ill: Springfield	5	2	0	1	0				
Ind: Indianapolis	20	3	0	1	0				
Iowa: Iowa City	21	4	0	1	6	95	6	95	0
Kans: Topeka	20	4	0	2	4	65	4	65	0
Ky: Frankfort	18	2	0	1	0				
La: New Orleans	20	2	0	0	10	144	(b)		
Maine: Augusta	21	1	0	0	10	124	10	124	0
Md: Baltimore	21	1	0	0	5	38	5	38	0
Mass: Lawrence	21	2	0	0	7	69	7	69	0
Winchester	20	1	0	0	9	260	9	260	0
Mich: Lansing	21	1	0	0	9	83	9	83	8
Minn: Minneapolis	14	2	0	1	3	54	3	54	15
Miss: Jackson	0				0				
Mo: Jefferson City	21	2	0	1	8	96	8	96	0
Mont: Helena	18	2	0	1	2	11	2	11	0
Nebr: Lincoln	20	13	1	3	1	3	1	3	1
Nev: Las Vegas	20	2	0	1	0				
N.H: Concord	0				0				
N.J: Trenton	21	1	0	0	10	126	10	126	3
N. Mex: Santa Fe	2	2	0	1	0				
N.Y: Albany	11	1	0	0	0				
Buffalo	20	1	0	0	0				
New York City	0				0				
N.C: Gastonia	21	7	1	2	3	47	(b)		
N. Dak: Bismarck	20	4	0	2	4	33	4	33	0
Ohio: Cincinnati	0				0				
Columbus	0			0	0				
Painesville	21	1	0	0	8	123	8	123	31
Okla: Oklahoma City	9	2	0	1	0				
Ponca City	0				0				
Oreg: Portland	20	0	0	0	6	57	6	57	2
Pa: Harrisburg	16	2	0	1	1	1	1	1	0
P.R: San Juan	0				0				
R.I: Providence	19	1	0	0	0				
S.C: Columbia	9	3	0	0	6	221	6	221	0
S. Dak: Pierre	0				0				
Tenn: Nashville	18	1	0	1	5	71	5	71	5
Tex: Austin	19	3	1	1	5	89	(b)		
El Paso	20	4	1	1	0				
Utah: Salt Lake City	28	2	0	1	2	5	2	5	1
Vt: Barre	15	2	0	1	8	123	8	123	7
Va: Richmond	18	2	0	0	1	17	1	17	1
Wash: Seattle	9	0	0	0	5	118	(b)		
Spokane	11	1	0	0	0				
W. Va: Charleston	19	3	0	1	6	89	5	49	3
Wisc: Madison	19	2	0	1	8	38	8	38	1
Wyo: Cheyenne	14	6	0	2	0				
Network summary	[illegible]	13	0	1	177	94	6	78	4

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

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2. Air Surveillance Network
June 1973

National Environmental Research Center—Las Vegas,[1] Environmental Protection Agency

The Air Surveillance Network[2] (ASN), operated by the National Environmental Research Center—Las Vegas (NERC-LV), consists of 49 active and 73 standby sampling stations located in 21 western States (figures 2 and 3). The network is operated in support of nuclear testing sponsored by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), and at any other designated testing sites.

The stations are operated by State health department personnel and by private individuals on a contract basis. All active stations are operated continuously with filters being exchanged over periods generally ranging from 24 to 72 hours. The standby stations were activated on June 29 to monitor radioactive fallout from a nuclear detonation conducted by the People's Republic of China on June 26, 1973. However, many of the State and federal agencies at which standby sampling stations are located were closed over the weekend of June 30–July 1 resulting in only one or two samples being collected at 46 locations in June. All samples are mailed to the NERC-LV unless special retrieval is arranged at selected locations in response to known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

Results

Table 2 presents the average gross beta concentrations in air for each of the network stations. The minimum reporting concentration for gross beta is 0.1 pCi/m^3. For reporting purposes, concentrations less than 1.0 pCi/m^3 are reported to one significant figure, and those equal to or greater than 1.0 pCi/m^3 are reported to two significant figures. For averaging purposes, individual concentration values less than the minimum detectable concentration (MDC) (0.06 pCi/m^3 for a 350 m^3 sample) are set equal to the minimum detectable concentration. Reporting and roundoff conventions are indicated as follows:

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[1] Formerly the Western Environmental Research Laboratory.

[2] The ASN is operated under a Memorandum of Understanding (No. AT-(26-1)-539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

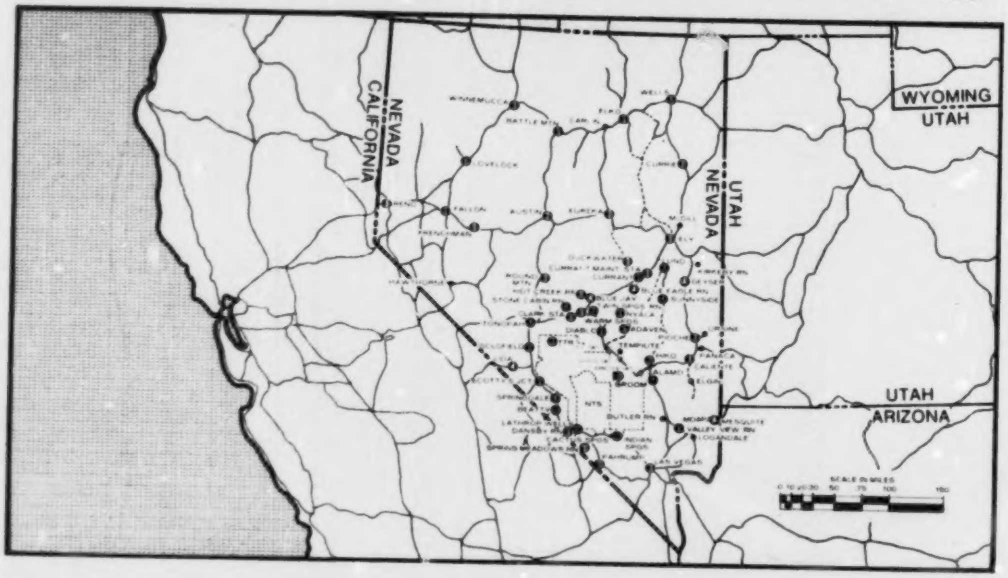
NEVADA
CALIFORNIA
WYOMING
UTAH
UTAH
NEVADA
UTAH
ARIZONA
WINNEMUCCA
BATTLE MTN
CARLIN
ELKO
WELLS
LOVELOCK
CURRIE
RENO
FALLON
AUSTIN
EUREKA
McGILL
FRENCHMAN
ELY
DUCKWATER
CURRANT MAINT STA
CURRANT
LUND
HAWTHORNE
ROUND MTN
BLUE EAGLE RN
SUNNYSIDE
HOT CREEK RN
STONE CABIN RN
BLUE JAY
TWIN SPGS RN
CLARK STA
NYALA
WARM SPGS
TONOPAH
DIABLO
ADAVEN
PIOCHE
TEMPIUTE
GOLDFIELD
HIKO
PANACA
CALIENTE
ALAMO
SCOTTY'S JCT
RACHEL
ELGIN
NTS
SPRINGDALE
BEATTY
BUTLER RN
MESQUITE
LATHROP WELLS
VALLEY VIEW RN
LOGANDALE
INDIAN SPGS
CACTUS SPGS
SPRING MEADOW RN
PAHRUMP
LAS VEGAS
SCALE IN MILES
0 10 20 30 50 75 100 150

Figure 2. NERC-LV Air Surveillance Network stations in Nevada

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Concentration (pCi/m³)	Reported value of concentration above MDC (pCi/m³)	Reported value of concentration concentration below MDC (pCi/m³)
<0.05	<0.1	<0.1
≧ .05 <0.15	.1	< .1
≧ .15	As calculated and rounded	< calculated MDC

As shown in table 2, the highest gross beta concentration within the network was 0.2 pCi/m³ at Diablo, Nev. No radionuclides were identified by gamma spectrometry on any filters or charcoal cartridges during June.

Complete copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA regional offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC-LV upon written request.

Table 2. Summary of gross beta radioactivity concentrations in air, June 1973

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average ᵃ
Ariz:	Kingman	30	<0.1	<0.1	<0.1
	Phoenix	2	<.1	<.1	<.1
	Seligman	28	.1	<.1	.1
	Winslow	2	<.1	<.1	<.1
Ark:	Little Rock	1	<.1	<.1	<.1
Calif:	Baker	23	.1	<.1	.1
	Barstow	30	<.1	<.1	<.1
	Bishop	30	<.1	<.1	<.1
	Death Valley Junction	29	<.2	<.1	<.1
	Furnace Creek	27	<.1	<.1	<.1
	Lone Pine	27	<.1	<.1	<.1
	Needles	27	.1	<.1	.1
	Ridgecrest	30	.1	<.1	.1
	Shoshone	30	<.1	<.1	<.1
Colo:	Denver	1	<.1	<.1	<.1
Idaho:	Boise	2	<.1	<.1	<.1
	Idaho Falls	2	<.1	<.1	<.1
	Preston	1	<.1	<.1	<.1
	Twin Falls	2	<.1	<.1	<.1
Iowa:	Iowa City	2	<.1	<.1	<.1
La:	Lake Charles	2	<.1	<.1	<.1
	Monroe	2	<.1	<.1	<.1
	New Orleans	2	<.1	<.1	<.1
Minn:	Minneapolis	1	<.1	<.1	<.1
Mo:	Clayton	1	<.1	<.1	<.1
	Joplin	2	<.1	<.1	<.1
Nebr:	North Platte	2	<.1	<.1	<.1
Nev:	Alamo	29	<.1	<.1	<.1
	Austin	18	.1	<.1	.1
	Battle Mountain	2	<.1	<.1	<.1
	Beatty	29	<.1	<.1	<.1
	Blue Eagle Ranch (Currant)	29	.1	<.1	.1
	Blue Jay	30	<.1	<.1	<.1
	Caliente	29	<.1	<.1	<.1
	Currant Ranch	29	<.2	<.1	<.1
	Diablo	30	.2	<.1	.1
	Duckwater	27	<.1	<.1	<.1
	Elko	2	<.1	<.1	<.1
	Ely	28	<.1	<.1	<.1
	Eureka	29	<.1	<.1	<.1
	Fallini's Twin Springs Ranch	30	<.1	<.1	<.1
	Fallon	2	<.1	<.1	<.1
	Geyser Maintenance Station	29	<.1	<.1	<.1
	Goldfield	30	<.2	<.1	<.1
	Groom Lake	18	.1	<.1	.1
	Hiko	30	<.1	<.1	<.1
	Indian Springs	30	<.1	<.1	<.1
	Las Vegas	21	.1	<.1	.1
	Lathrop Wells	28	<.1	<.1	<.1
	Lida	24	<.1	<.1	<.1
	Lovelock	1	<.1	<.1	<.1
	Lund	30	<.1	<.1	<.1
	Mesquite	30	<.1	<.1	<.1
	Nyala	30	<.1	<.1	<.1

See footnote at end of table.

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Table 2. Summary of gross beta radioactivity concentrations in air, June 1973—continued

Location		Number of samples	Concentration (pCi/m^3)		
			Maximum	Minimum	Average ᵃ
	Pahrump	27	<.2	<.1	<.1
	Pioche	27	<.1	<.1	<.1
	Reno	2	<.2	<.1	<.1
	Round Mountain	30	<.1	<.1	<.1
	Scotty's Junction	27	.1	<.1	.1
	Stone Cabin Ranch	30	<.1	<.1	<.1
	Sunnyside	30	<.1	<.1	<.1
	Tonopah	26	<.1	<.1	<.1
	Tonopah Test Range	29	.1	<.1	.1
	Warm Springs	28	<.1	<.1	<.1
	Warm Springs Ranch	30	<.1	<.1	<.1
	Wells	2	<.1	<.1	<.1
	Winnemucca	2	<.1	<.1	<.1
N. Mex:	Albuquerque	1	<.1	<.1	<.1
	Carlsbad	1	<.1	<.1	<.1
Okla:	Muskogee	2	<.1	<.1	<.1
Oreg:	Burns	2	<.1	<.1	<.1
	Medford	10	<.1	<.1	<.1
S. Dak:	Aberdeen	1	<.1	<.1	<.1
	Rapid City	1	<.1	<.1	<.1
Tex:	Abilene	2	<.1	<.1	<.1
	Amarillo	2	<.1	<.1	<.1
	Fort Worth	2	<.1	<.1	<.1
Utah:	Cedar City	26	<.1	<.1	<.1
	Delta	30	<.2	<.1	<.1
	Dugway	2	<.1	<.1	<.1
	Enterprise	2	<.1	<.1	<.1
	Garrison	29	.1	<.1	.1
	Logan	2	<.1	<.1	<.1
	Milford	30	<.1	<.1	<.1
	Monticello	2	<.1	<.1	<.1
	Parowan	2	<.1	<.1	<.1
Utah:	Provo	2	<.1	<.1	<.1
	Roosevelt	1	<.1	<.1	<.1
	Salt Lake City	2	<.1	<.1	<.1
	St. George	29	<.1	<.1	<.1
	Wendover	2	<.1	<.1	<.1
Wash:	Seattle	2	<.1	<.1	<.1
	Spokane	1	<.1	<.1	<.1
Wyo:	Rock Springs	8	<.1	<.1	<.1
	Worland	2	<.1	<.1	<.1

ᵃ Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reportable value of 0.1 pCi/m^3 is reported as <0.1.

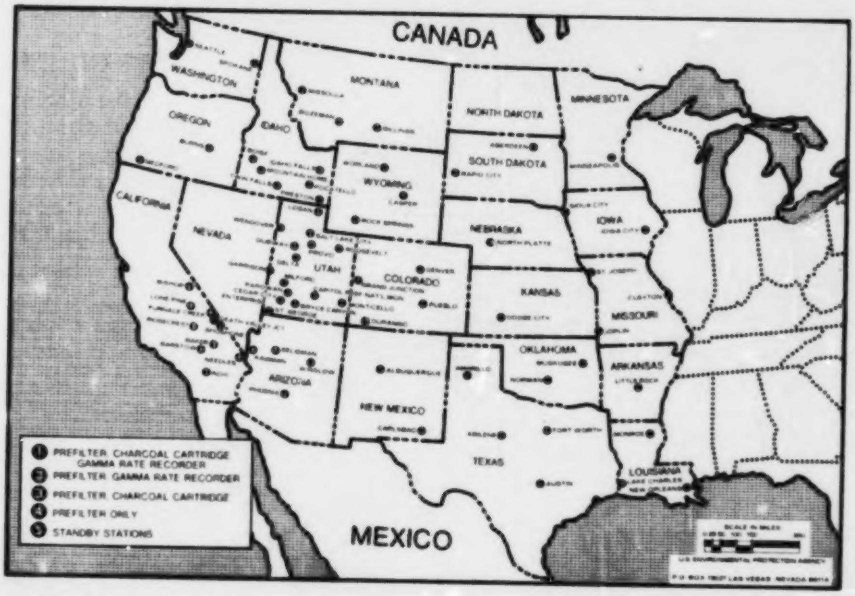
CANADA
WASHINGTON
OREGON
IDAHO
MONTANA
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
WYOMING
CALIFORNIA
NEVADA
UTAH
COLORADO
NEBRASKA
IOWA
KANSAS
MISSOURI
OKLAHOMA
ARKANSAS
ARIZONA
NEW MEXICO
TEXAS
LOUISIANA
MEXICO
PREFILTER, CHARCOAL CARTRIDGE GAMMA RATE RECORDER
PREFILTER, GAMMA RATE RECORDER
PREFILTER, CHARCOAL CARTRIDGE
PREFILTER ONLY
STANDBY STATIONS
SCALE IN MILES
U.S. ENVIRONMENTAL PROTECTION AGENCY

Figure 3. NERC-LV Air Surveillance Network outside Nevada

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3. Canadian Air and Precipitation Monitoring Program[a] June 1973

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 4), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for June 1973 are presented in table 3.

Table 3. Canadian gross beta radioactivity in surface air and precipitation, June 1973

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	5	0.02	<0.01	0.02	3	0.2
Coral Harbour	5	.02	<.01	.01	8	.2
Edmonton	5	.02	.01	.01	1	.1
Ft. Churchill	4	.01	<.01	<.01	42	.4
Frederiction	6	.02	<.01	.01	5	.4
Goose Bay	6	<.01	<.01	<.01	.2	.2
Halifax	4	.01	.01	.01	5	.6
Inuvik	6	.01	<.01	.01	18	.7
Montreal	5	.02	<.01	.01	5	.4
Moosonee	4	.01	<.01	.01	17	.8
Ottawa	5	.02	.01	.01	7	.8
Quebec	6	.01	<.01	.01	6	.7
Regina	5	.02	.01	.01	12	.9
Resolute	5	.01	<.01	.01	23	.1
St. John's, Nfld	1	<.01	<.01	<.01	12	1.8
Saskatoon	6	.01	.01	.01	8	.9
Sault Ste. Marie	5	.02	<.01	.01	25	1.6
Thunder Bay	6	.02	<.01	.01	8	.7
Toronto	4	.02	.01	.02	8	.5
Vancouver	5	.01	<.01	.01	9	.5
Whitehorse	4	.01	<.01	.01	13	.2
Windsor	6	.02	.01	.01	3	.6
Winnipeg	5	.02	.01	.02	9	.9
Yellowknife	4	.01	<.01	<.01	30	.4
Network summary	115	0.02	<0.01	0.01	12	0.6

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[a] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

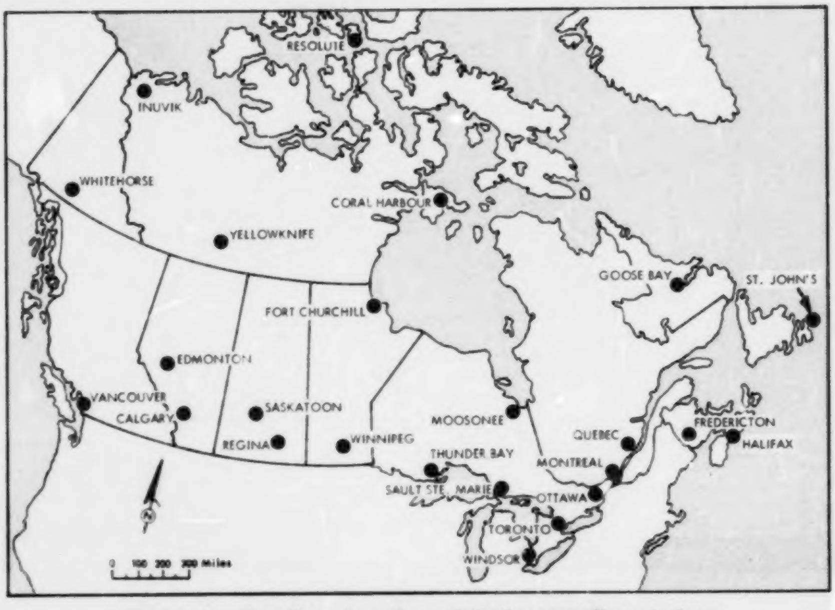
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
MOOSONEE
REGINA
WINNIPEG
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
N
0 100 200 300 Miles

Figure 4. Canadian air and precipitation sampling stations

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4. Pan American Air Sampling Program June 1973

Pan American Health Organization and U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The June 1973 air monitoring results from the participating countries are given in table 4.

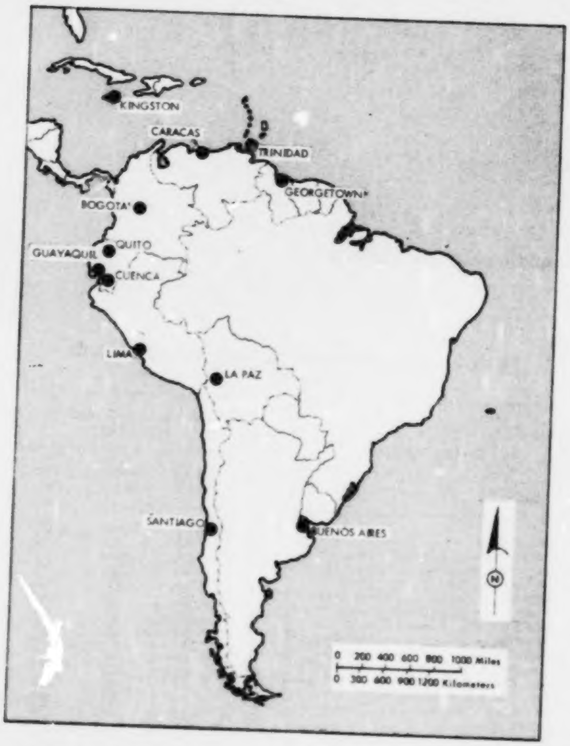

Figure 5. Pan American Air Sampling Program stations

Table 4. Summary of gross beta radioactivity in Pan American surface air, June 1973

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	14	0.02	0.00	0.01
Chile:	Santiago	30	.03	.00	.02
Colombia:	Bogota	16	.01	.00	.00
Ecuador:	Cuenca	6	.00	.00	.00
	Guayaquil	13	.03	.00	.01
	Quito	0			
Guyana:	Georgetown	0			
Jamaica:	Kingston	0			
Peru:	Lima	12	.03	.00	.01
Venezuela:	Caracas	17	.04	.00	.02
West Indies:	Trinidad	0			
Pan American summary		108	0.04	0.00	0.01

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

5. California Air Sampling Program June 1973

Bureau of Radiological Health
California State Department of Public Health

The Bureau of Radiological Health of the California State Department of Public Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 6.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Public Health where they are analyzed for their radioactive content.

Airborne particles are collected by a continu-

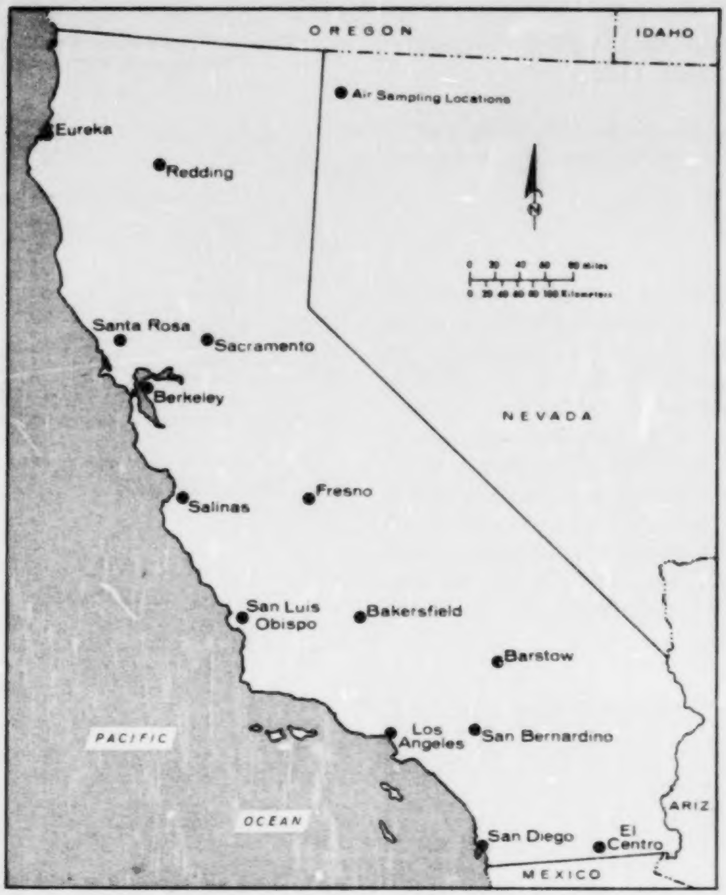
OREGON
IDAHO
Air Sampling Locations
0 20 40 60 80 Miles
0 20 40 60 80 100 Kilometers
N
Eureka
Redding
Santa Rosa
Sacramento
Berkeley
NEVADA
Salinas
Fresno
San Luis Obispo
Bakersfield
Barstow
PACIFIC
OCEAN
Los Angeles
San Bernardino
ARIZ
San Diego
El Centro
MEXICO

Figure 6. California air sampling program stations

ous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity 72 hours after the end of the collection period. The daily samples are then composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. Table 5 presents the monthly gross beta radioactivity in air for June 1973. The monthly sample results are presented quarterly.

Table 5. Gross beta radioactivity in California air June 1973

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	29	0.79	0.06	0.20
Barstow	30	.53	.05	.14
Berkeley	29	.08	.00	.02
El Centro	8	.38	.05	.11
Eureka	27	.08	.00	.02
Fresno	28	1.02	.04	.19
Los Angeles	28	.08	.00	.04
Redding	28	.19	.02	.06
Sacramento	29	.46	.03	.10
Salinas	29	1.85	.00	.25
San Bernardino	29	.28	.02	.08
San Diego	28	.10	.02	.04
San Luis Obispo	29	.71	.02	.10
Santa Rosa	30	.26	.00	.06
Summary	381	1.85	0.00	0.10

REFERENCES

(1) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(3) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(4) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(5) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Strontium-90 in Human Vertebrae, 1971[1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

Since 1961, the strontium-90 content of human vertebrae has been measured by the Health and Safety Laboratory (HASL). Data obtained from these programs have been used to construct models that attempt to explain the variation of strontium-90 concentrations in bone with age and time. The main purpose of the work is to provide estimates of the radiation dose to man that has resulted from the fallout from nuclear weapons tests. In attempting to construct the models it has become apparent that there are serious gaps in our knowledge of mineral metabolism, especially that of children. The survey data have therefore been used, at times, to gain some insight into the metabolism of strontium by children. This approach is very difficult because of the small numbers of specimens that are available and the absence of an exact knowledge of the diet of the children from whom specimens were obtained. Because it is unlikely that much direct experimental data from tracer studies on children will ever be available, we will be forced to rely on the indirect evidence from survey results to construct our models.

During 1971, 254 specimens of human vertebrae were analyzed, including 56 from children and 37 from adults obtained in New York City and 91 from children and 70 from adults obtained in San Francisco. A summary of the results of strontium-90 determinations is given in table 1.

Table 1. Strontium-90 to calcium ratios in human vertebrae, 1971

Age	Strontium-90 to calcium ratios (pCi ^{90}Sr/g Ca)	
	New York City	San Francisco
0–1 month		0.68 (56)
0–4		.72 (9)
1–2	[a]1.90 (4)	
2–3		1.28 (8)
2–4	2.41 (4)	
5–13		1.65 (2)
1–2 year	3.25 (1)	1.81 (3)
2–3	1.74 (2)	1.16 (1)
3–4	2.65 (2)	1.47 (3)
4–5	2.00 (3)	1.43 (3)
5–6	2.28 (2)	1.74 (2)
6–7	2.30 (1)	.61 (1)
7–8		1.62 (1)
8–9	2.52 (1)	
9–10	1.99 (1)	.58 (2)
10–11		.69 (1)
11–12	2.01 (1)	.81 (1)
13–14	2.42 (3)	
14–15	2.13 (3)	1.46 (1)
15–16	2.30 (2)	
16–17	2.42 (4)	
17–18	1.89 (7)	
18–19	1.90 (11)	.94 (2)
19–20	1.71 (5)	
20–30	1.63 (11)	1.22 (3)
30–40	1.44 (9)	.98 (7)
40–50	1.42 (4)	.69 (10)
50–60	1.15 (4)	.74 (19)
60–70	1.34 (3)	.86 (18)
70–80	1.38 (4)	.87 (11)
80–90		.95 (2)
90–100	1.76 (2)	

[a] Numbers in parenthesis indicate number of samples.

The strontium-90 to calcium ratios for adults are relatively constant, as has previously been observed. The variations about the mean are typical of such survey measurements. The average values and standards deviations for adult vertebrae in 1971 were 1.40 ± .37 pCi/g Ca in New York and .80 ± .35 pCi/g Ca in San Francisco.

The strontium-90 to calcium ratios for children's bones show more variation than the adult values. Generally higher values are obtained for children than adults, but most values are within a factor of 1½ to 2 of the adult values. The highest value measured in New York vertebrae during 1971 was 3.25 pCi/g Ca for a 1½-year-old child and in San Francisco 2.53 pCi/g Ca for a 5-year-old child.

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[1] Summarized from Fallout Program Summary Report, HASL-257 (July 1, 1972).

Bone model

An improved bone model has been formulated to correlate the strontium-90 concentrations in diet and bone. The model as it applied to adult vertebrae is described by the equation:

$$B_n = cD_n + g\sum_{m=0}^{\infty} D_{n-m} e^{-m\lambda} \qquad \ldots (1)$$

where,

B_n = ^{90}Sr concentration in vertebrae in the year n (pCi)

D_n = ^{90}Sr concentration in diet from mid-year in the year n–1 to mid year in the year n (pCi)

c = short-term retention of ^{90}Sr in bone

g = long-term retention of ^{90}Sr in bone

$1 - e^{-\lambda}$ = bone turnover rate plus radioactive decay (yr^{-1})

The formula describes a two compartment model, one compartment associated with short-term retention of strontium on bone surfaces and another compartment in which the strontium is more tightly retained in bone. The parameters c and g are independent and not related to the previously used concept of observed ratio, since retention can also be associated with processes other than new bone formation. The factors c, g, and λ are constant for adults ($\geq$ age 20 years) but are age dependent for children.

Variations of the above bone model were investigated, such as the inclusion of an exponential in the short-term retention term. The best fit in this form, however, was with a very high order exponential, indicating essentially complete turnover of the short-term component during the course of a year.

The above formula for the bone model maintains a desired simplicity and yet gives adequate description of the year-to-year changes in strontium-90 content of bone. The values obtained for the model parameters allow reasonable interpretation.

Strontium-90 in adult vertebrae

The observed strontium-90 concentrations in adult vertebrae are shown in figure 1. Additional approximate values for the earliest years of contamination (1954–59) in New York from the data of Kulp and Schulert (*1*) have also been included. The adult data include only samples from individuals age 20 years or older in 1954, thus representing adult metabolism for the entire contamination period.

A definite decreasing trend in the observed values in adult vertebrae is apparent since 1965, corresponding to decreases in dietary strontium-90 intake. The relatively large standard deviations about the average values preclude extremely accurate determination of the actual decreases and thus the bone turnover rates; however, these are becoming more firmly established as additional years of data accumulate during periods of decreasing strontium-90 levels in diet.

From regression analysis of the measured New York adult diet and vertebrae values through 1970 in the above bone model, one infers a turnover rate of 13 percent per year for adult vertebrae. This value also fits the 1971 results within the standard deviation, but based on least squares criteria from the average observed values, a turnover rate of 18 percent per year is more appropriate for the data through 1971. This latter value also gives the best fit to the San Francisco data through 1971. These best fits to the observed data using the bone model are shown in figure 1.

The model shows peak strontium-90 concentrations in adult vertebrae in 1965, in agreement with observations. Subsequent decreases are achieved with a turnover rate which is reasonable, in view of the remodeling and diffusion processes occurring in bone. The bone model appears to be quite responsive to strontium-90 levels in diet and gives very satisfactory fits to the observed strontium-90 levels in vertebrae.

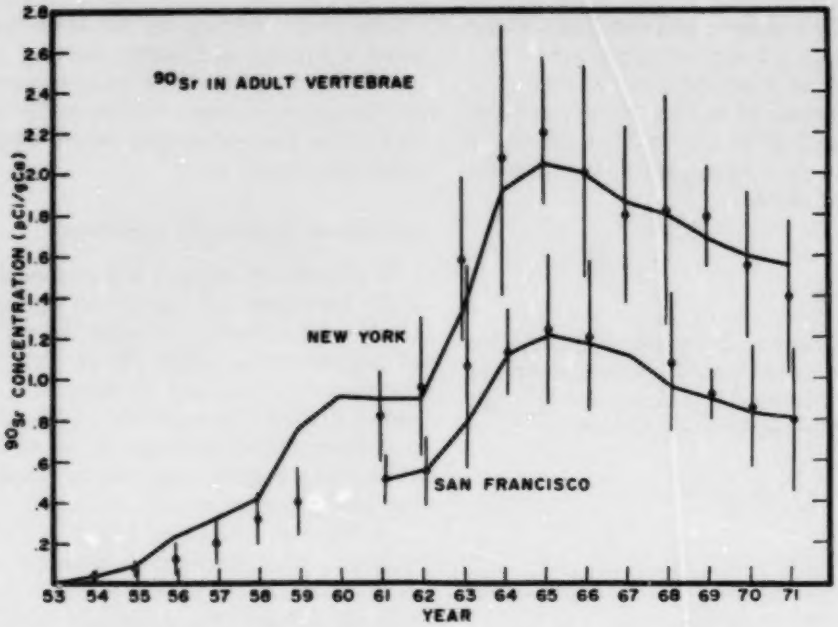

Figure 1. Strontium-90 in adult vertebrae—observations (points with standard deviations) and bone model predictions (solid line)

Strontium-90 in children's bone

The strontium-90 concentration in children's bone can be determined by the formula

$$B_{i,n} = (c_i+g_i)\,D_{i,n} + [B_{i-1,n-1} - c_{i-1}\,D_{i-1,n-1}]\,e^{-\lambda_i}$$

The bone model parameters are defined as before. The subscript i indicates the age dependence.

For the newborn, the strontium-90 concentration can be related empirically to the mother's diet. The strontium-90 to calcium ratio in bone of newborns varies from .1 to .2 times the strontium-90 to calcium ratio in diet of the mother during the year prior to the birth. An average of about .16 is obtained from the survey data.

From the regression results for children, one infers that a one compartment, single exponential model ($c_i = 0$) applies to children under age 8 years. The one compartment formulation of the above model closely corresponds to the previously used Rivera bone model (*2*). The undifferentiated nature of bone of young children and the relatively high turnover rates justify the one compartment treatment.

The turnover rates and relative retention as a function of age are shown in figures 2 and 3. The turnover rates reflect bone growth activity and are highest for the youngest children. Nearly 100 percent per year turnover rate is indicated for the 0–1 year age range. A relatively high turnover rate, about 40 percent, is maintained through the preteenage years. The values then decrease to the adult value.

The relative retention of strontium-90 in bone is the fractional retention of the dietary strontium-90 intake (c_i+g_i) per gram of skeletal calcium. The highest efficiency for strontium-90 retention is obtained for the youngest children. Increased efficiency associated with increased growth is also indicated for children in the early teenage years.

The magnitude of the relative retention was determined by assuming that vertebrae behavior is representative of entire skeletal behavior. This assumption becomes less satisfac-

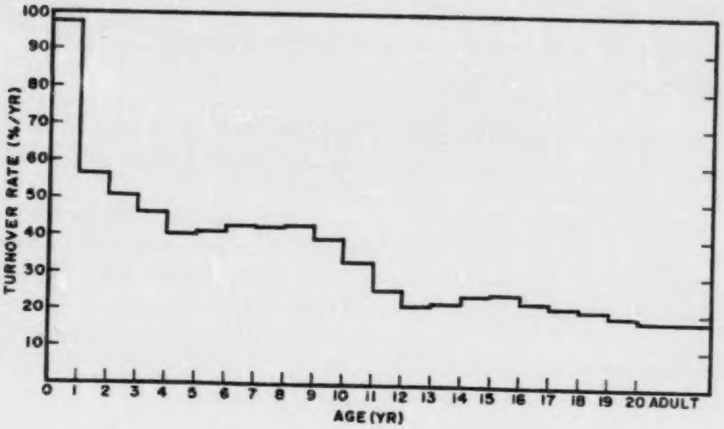

Figure 2. Turnover rates for vertebrae inferred from the two component bone models

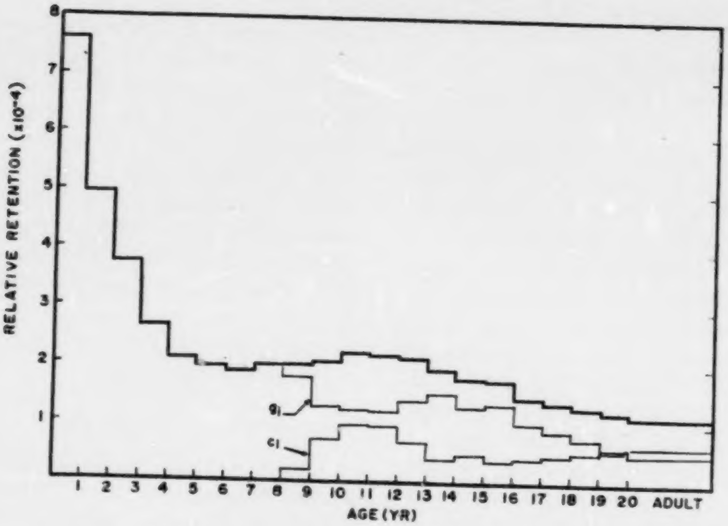

Figure 3. Retention of strontium-90 per gram skeletal calcium (The upper histogram is the total relative retention, c_1 is the short-term component, and g_1 is the long-term component)

tory for older children and adults. Initial estimates of body burden will be high and estimates at later times will be low, assuming less initial retention and slower turnover rates for compact bone. Integral results should be more representative for the entire skeleton, such as the cumulative dose results following a period of strontium-90 intake of 1 year or more.

REFERENCES

(1) KULP, J. L. and A. R. SCHULERT. Strontium-90 in man. Science 619:136 (1962).

(2) RIVERA, J. and J. H. HARLEY. The HASL Bone Program, 1961–1964, HASL—163. U.S. Atomic Energy Commission (August 1965).

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Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors annual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual." [1]

Summaries of the environmental radioactivity data follow for the Lawrence Livermore Laboratory and the Shippingport Atomic Power Station.

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[1] Title 10, Code to Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Lawrence Livermore Laboratory[2] January–December 1971

University of California
Livermore, Calif.

The Lawrence Livermore Laboratory (LLL) (figure 1) is located approximately 50 miles southeast of San Francisco in the Livermore-Amador Valley of California. Shielded from the ocean by the western hills, the Livermore Valley has a warm, dry climate. Prevailing winds are from the west and southwest during April through September, and from the northeast during the remainder of the year. Annual rainfall is about 14 inches with most of the precipitation occurring during the winter months. Surface water drainage from the valley is from east to west through various arroyos, with outflow near Sunol in the southwestern corner of the valley.

Agriculture is the principal activity in the Livermore Valley. Roses, grain, hay, and grapes are the major products. Several cattle and sheep ranches surround the Livermore Laboratory.

The Livermore Laboratory occupies an area of 1 square mile, approximately 3 miles east of the city of Livermore. Livermore and Pleasanton, with a combined population of 45,000 are the populated areas of primary interest to the Livermore site.

An environmental sampling program is maintained to provide information regarding the effectiveness of control measures and to determine whether any radiological changes in the environment are the result of laboratory operations. The sampling program includes air particulates, soil, domestic water, sewer effluent, sewage plant products, milk, and vegetation. These samples are analyzed for gross radioactivities as well as for the activity of specific radionuclides of interest. In addition, environmental background radiation is measured at numerous locations in the vicinity of the Livermore Laboratory by means of thermoluminescent detectors.

Atmospheric radioactivity

The concentrations of various airborne radioactive substances were measured at 16 air sampling stations situated throughout the Livermore Valley. Their locations are shown in figures 1 and 2. The six samplers located on the laboratory perimeter use 80 square-inch Whatman 41 filters. The average sampling rate is 25 cfm. The remaining samplers, located offsite, use 36 square-inch HV-70 (cellulose-asbestos) filters and operate at an average flow rate of 4 cfm. These air samplers are situated in such a manner providing reasonable assurance that a significant release of airborne particulate radioactivity from the laboratory would be detected regardless of the local meteorology at the time of the release. Filters are changed weekly during the winter months and twice

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[2] Summarized from Environmental Monitoring at Major U.S. Atomic Energy Commission Contractor Sites, Lawrence Livermore Laboratory, January–December 1971.

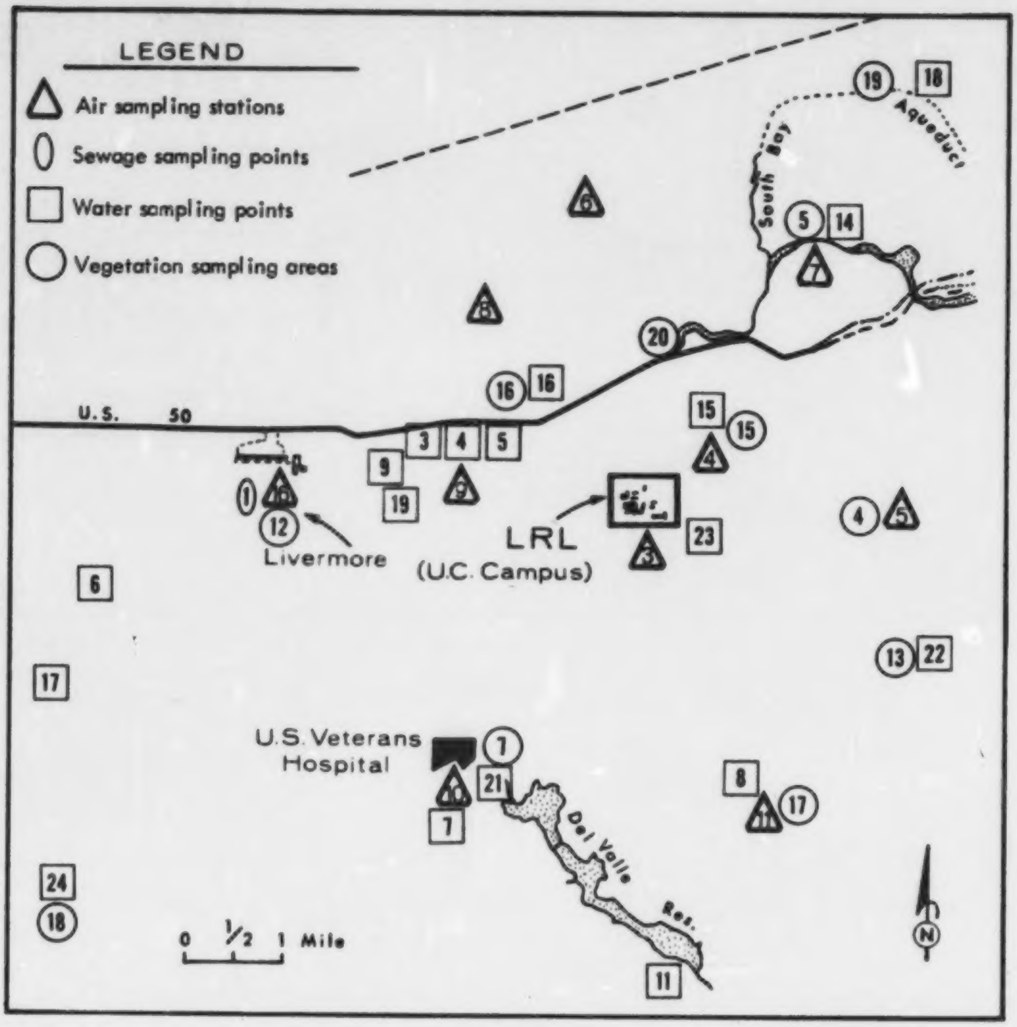
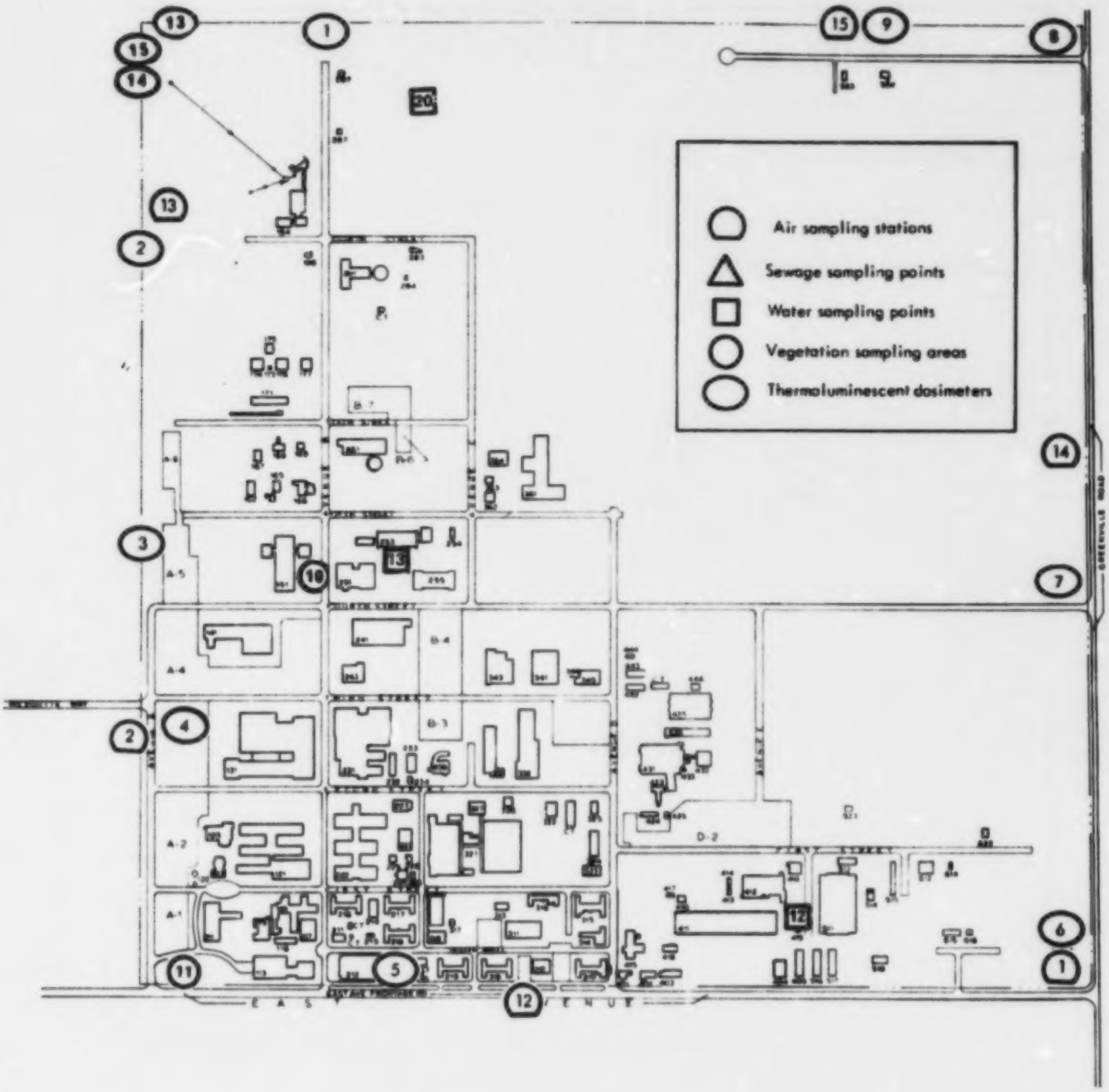

LEGEND
Air sampling stations
Sewage sampling points
Water sampling points
Vegetation sampling areas
U.S. 50
South Bay Aqueduct
Livermore
LRL
(U.C. Campus)
U.S. Veterans Hospital
Del Valle Res.
0 1/2 1 Mile
N

Figure 1. Lawrence Livermore Laboratory offsite environmental sampling locations

weekly during the summer to avoid excessive mass loading. An automatic radiation detection system with gas-flow proportional detectors is used to determine gross alpha and beta activities deposited on the filters after radon decay. The filters are also assayed for gamma-emitting radionuclides by means of a specially designed Ge(Li) detector equipped with a Compton suppression system (*1*).

No gross alpha activity above the 1 fCi/m^3 detection limit was observed on the filters. The gross beta activities averaged over 3-month periods and the annual average radioactivities are shown for each sampling location in table 1, where they may be compared with the appropriate AEC standards. A significant fraction of the beta activities deposited on the filters is due to global fallout produced by nuclear weapons tests and by cosmic-ray interactions with the atmosphere. This is shown in table 2 which


Air sampling stations
Sewage sampling points
Water sampling points
Vegetation sampling areas
Thermoluminescent dosimeters
13
1
15
9
8
15
14
20
13
2
14
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11
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12
A-5
A-4
A-2
A-1
B-4
B-3
D-2
E A S T
E N U E

Figure 2. Lawrence Livermore Laboratory onsite environmental sampling locations

lists the activities of the more abundant gamma-emitting radionuclides in monthly composite samples collected by the six laboratory perimeter samplers. These data exhibit the typical spring increase in surface air radioactivity due to the enhanced transport of relatively high activity stratospheric air into the troposphere during this time of year. In addition, the data shows the influence of the French and Chinese atmospheric nuclear weapons tests of 1970 which injected significant quantities of fresh debris into the stratosphere. This is illustrated

Table 1. Airborne particulate activity within the Livermore Valley, January–December 1971

Sampling location [a]	Gross beta radioactivity (pCi/m³)									Percent AEC standard [b]
	January-March		April-June		July-September		October-December		Annual average	
	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average		
1	0.45 ± 1%	0.10	0.24 ±1%	0.18	0.22 ±4%	0.13	0.090 ± 2%	0.050	0.12	12
2	.25 ± 1%	.068	.25 ±1%	.18	.22 ±1%	.12	.12 ± 5%	.042	.11	11
3	.15 ± 6%	.073	.17 ±3%	.13	.15 ±3%	.083	.044 ± 9%	.027	.080	8
4	.55 ± 2%	.14	.31 ±2%	.23	.29 ±2%	.16	.083 ± 5%	.056	.15	15
5	.34 ± 2%	.084	.26 ±2%	.16	.22 ±2%	.11	.040 ±10%	.026	.095	10
6	.30 ± 2%	.14	.17 ±3%	.12	.28 ±2%	.093	.051 ± 8%	.031	.096	10
7	.051 ±12%	.031	.16 ±3%	.12	.15 ±3%	.075	.051 ± 8%	.027	.063	6
8	.10 ± 6%	.042	.24 ±2%	.13	.19 ±3%	.091	.053 ± 7%	.023	.072	7
9	.85 ± 2%	.098	.22 ±3%	.18	.19 ±3%	.10	.071 ± 6%	.040	.11	11
10	.13 ± 3%	.096	.24 ±2%	.13	.13 ±3%	.067	.050 ± 8%	.027	.080	8
11	.30 ± 2%	.073	.19 ±3%	.12	.18 ±3%	.071	.049 ± 8%	.024	.072	7
12	.41 ± 1%	.11	.28 ±1%	.21	.29 ±2%	.15	.089 ± 3%	.051	.13	13
13	.33 ± 2%	.10	.28 ±1%	.19	.22 ±2%	.13	.15 ± 2%	.053	.12	12
14	.81 ± 1%	.20	.56 ±1%	.41	.45 ±2%	.26	.15 ± 2%	.030	.24	24
15	.38 ± 1%	.097	.26 ±1%	.19	.24 ±2%	.13	.09 ± 3%	.048	.12	12
16	.53 ± 2%	.11	.24 ±3%	.16	.22 ±3%	.10	.064 ± 6%	.037	.10	10

[a] See figures 1 and 2 for sampling locations.
[b] The AEC standard is 1 pCi/m³.

Table 2. Results of gamma-ray spectral measurements of Livermore Laboratory perimeter air filters January–December 1971

Month (1971)	Concentration (fCi/m³)							
	^{144}Ce	^{141}Ce	^{125}Sb	^{7}Be	^{103}Ru	^{106}Ru	^{137}Cs	^{95}Zr
January	9.9 ±3%	3.4 ± 8%	0.78 ±18%	55 ±4%	3.9 ± 8%	3.6 ±25%	0.98 ± 9%	3.9 ±4%
February	16 ±3%	4.9 ± 5%	1.3 ±20%	54 ±5%	7.1 ± 6%	6.2 ±26%	1.2 ±12%	7.6 ±3%
March	47 ±1%	18 ± 2%	2.8 ±11%	83 ±4%	26 ± 2%	21 ± 9%	3.6 ± 5%	36 ±1%
April	62 ±1%	15 ± 2%	3.3 ±15%	88 ±5%	16 ± 3%	28 ±12%	4.6 ± 6%	50 ±1%
May	140 ±1%	20 ± 2%	9.1 ± 1%	130 ±4%	40 ± 9%	48 ± 9%	10 ± 5%	95 ±1%
June	73 ±2%	7.3 ± 6%	3.7 ±22%	57 ±9%	140 ± 5%	32 ±17%	5.0 ±10%	37 ±2%
July	68 ±1%	3.9 ±12%	3.5 ±16%	63 ±6%	11 ± 7%	29 ± 7%	4.6 ± 5%	30 ±2%
August	100 ±1%	2.2 ±19%	6.6 ± 9%	160 ±3%	7.7 ± 8%	43 ± 8%	7.1 ± 5%	34 ±2%
September	56 ±2%	1.8 ±25%	4.0 ±14%	180 ±4%	2.8 ±20%	22 ±15%	4.3 ± 8%	13 ±3%
October	15 ±3%	.64 ±27%	.97 ±26%	82 ±4%	.48 ±42%	10 ±10%	1.3 ±12%	3.5 ±5%
November	34 ±3%	.53 ±58%	2.5 ±22%	220 ±3%	1.6 ±22%	16 ±17%	2.7 ±11%	5.5 ±5%
December	5.5 ±4%	5.4 ± 2%	.51 ±27%	40 ±4%	6.2 ± 3%	1.3 ±32%	.61 ±11%	.89 ±7%
Annual average	52	6.9	3.3	100	22	22	3.8	26
AEC standard [a]	2×10^5	5×10^6	9×10^5	4×10^7	3×10^6	2×10^5	5×10^5	1×10^6
Percent AEC	0.026	0.00014	0.00037	0.00025	0.00071	0.011	0.00076	0.0026

[a] Assumes the activity is in an insoluble form.

in figure 3 by the zirconium-95 to cesium-137 ratios which increased to a maximum value during the spring, due to the addition of relatively large quantities of zirconium-95 as expected with little or no further addition of fresh debris.

These monthly composite samples were also subjected to plutonium and uranium analyses by dry ashing and complete dissolution of the filters and subsequent radiochemical separation of the elements. The plutonium was isolated by ion-exchange techniques and detected by alpha spectrometry. The isotopic uranium analyses were performed by mass spectrographic methods. The results are provided in table 3. Inspection of the data reveals that the relative activities of plutonium-238 and plutonium-239 approximate those normally observed in global fallout. The decreasing values of the ratio undoubtedly are a result of the addition of fresh plutonium-239 from the recent atmospheric weapons tests, as well as depletion of the plutonium-238 produced by the 1964 SNAP generator burn-up. The uranium-235–uranium-238 ratios approximate the values observed in natural uranium.

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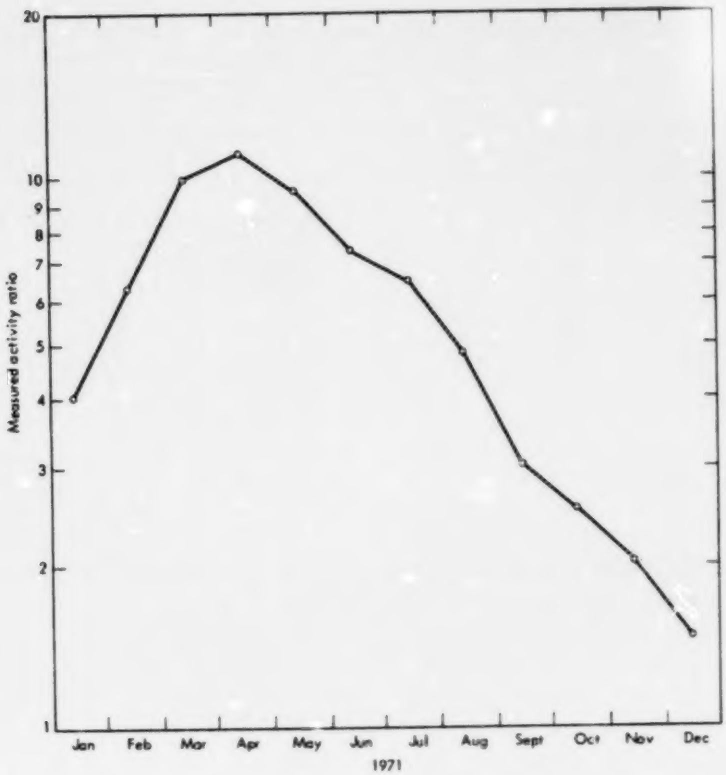

Figure 3. The measured ^{95}Zr-^{137}Cs activity ratios on air filters from LLL perimeter samplers

Table 3. Plutonium and uranium concentrations in Livermore Laboratory perimeter air filters January–December 1971

Month (1971)	Activity (aCi/m³)		^{238}Pu/^{239}Pu	Mass (pg/m³)		^{235}U/^{238}U
	^{238}Pu	^{239}Pu		^{235}U	^{238}U	
January	3.4 ± 6%	24 ±3%	0.14	0.22 ±2%	47. ±1%	0.0047
February	.83 ± 6%	9.2 ±3%	.09	.070 ±1%	10. ±2%	.0068
March	36 ± 6%	340 ±4%	.11	1.3 ±1%	170. ±1%	.0076
April	9.1 ± 7%	79 ±4%	.12	.25 ±1%	36. ±2%	.0069
May	5.7 ± 7%	110 ±4%	.054	.63 ±1%	100. ±1%	.0063
June	3.4 ±10%	76 ±5%	.045	.33 ±2%	49. ±2%	.0066
July	3.0 ±10%	65 ±5%	.046	.47 ±1%	74. ±2%	.0063
August	2.2 ±10%	47 ±5%	.047	.42 ±1%	62. ±2%	.0066
September	2.1 ±17%	49 ±4%	.043	.26 ±1%	36. ±1%	.0072
October	1.5 ±15%	26 ±6%	.057	.30 ±1%	64. ±1%	.0047
November	1.1 ±14%	27 ±4%	.041	.47 ±1%	47. ±1%	.010
December	.30 ±12%	4.7 ±4%	.064	.047 ±1%	6.7 ±2%	.0070
Annual average	5.7	71		0.40	58.	
AEC standard	1,000,000	1,000,000		1,900,000	15,000,000	
Percent of AEC standard	0.00057	0.0071		0.000021	0.00039	

[a] Assumes the activity is in an insoluble form.

The calculated annual lung doses to an adult resulting from inhalation of the radionuclides listed in tables 2 and 3 are shown in table 4. These were obtained by using the ICRP Lung Model (*2*) and making the following assumptions:

the radionuclides are present in an insoluble form,

the mean particle activity diameter is 1 micrometer, and

the activities of the radionuclides within the various body organs have obtained equilibrium.

We feel the first two assumptions are reasonable in view of the fact that the activities may be situated in insoluble silicate matrixes within particles that may range in size from 1/10 to several micrometers in diameter. This is the range usually observed in air pollution studies. Also, since global fallout has been with us for upwards of two decades, the third assumption should be valid for most radionuclides since their half-lives in the lung are short relative to the long exposure time. The data in table 4 shows that the resulting inhalation doses are minor with the greatest contribution (2.6 mrem) being due to cerium-144.

Table 4. Inhalation doses resulting from the air concentrations shown in tables 2 and 3

Radionuclide	Calculated annual lung dose (mrem)
Cerium-144	2.6
Cerium-141	.048
Antimony-125	.032
Beryllium-7	.064
Ruthenium-103	.22
Ruthenium-106	.36
Cesium-137	.060
Zirconium-95	.54
Plutonium-238	.012
Plutonium-239	.14
Uranium-235	.0016
Uranium-238	.032

Soil

A soil sampling program is currently underway to determine the surface distribution of various radionuclides that have been deposited within the Livermore Valley as a result of global fallout from atmospheric weapons tests as well as from possible laboratory effluents. A core sampling method was used to obtain the soil samples at various depths down to 20 cm for activity/depth profile studies. Each sample was collected over a surface area ranging between 250 cm^2 to 1,000 cm^2 by combining a minimum of 10 separate cores obtained over an approximate 30 m^2 area.

The samples were thoroughly dried and homogenized before undergoing analyses for the radionuclides of interest. During the initial phases of the program, a minimum of 50 grams of soil were subjected to either the HASL acid leach method (*3*) or a complete dissolution method by various outside contractors for the analysis of plutonium-238, plutonium-239, and strontium-90. Analysis of the leach residues from several samples for quality control purposes indicated that approximately 90 percent of the total plutonium activity in the samples was removed by this leach method. However, because of the possibility of large variations in the chemical and physical state of the plutonium that may appear in the environment, a capability was developed within LLL to completely dissolve 100-gram soil samples by acid dissolution techniques to gain increased analytical sensitivity and sample homogeneity. Standard ion-exchange techniques and alpha-pulse-height analyses are used to quantitate the plutonium content of the soil. Gamma spectral analyses were made by placing approximately 300 grams of soil on a Ge(Li) detector equipped with a Compton suppression system. These analyses provided quantitative data regarding the concentrations of cesium-137, cerium-144, zirconium-95, and potassium-40 in Livermore soils.

The results of the analyses are provided in table 5, and the sampling locations are shown in figure 4. The depth profile studies at sampling locations 9, 10, 11, and 15 indicate the artificially produced radionuclides do penetrate appreciably into the soil, probably as a result of leaching or mechanical mixing. Generally, the activity in the 15–20-cm layer is about a factor of 10 less than that in the top 1-cm layer, although wide variations may be observed. As expected, the activity of potassium-40 seems to be distributed fairly homogeneously with depth. Our analytical techniques generally made it possible to detect the activities of plutonium-239, strontium-90, cesium-137, and potassium-40 to a sampling depth of about

Table 5. Activity levels of various radionuclides in soil, January–December 1971

Sampling location	Depth (cm)	Concentration (fCi/g)						^{40}K concentration (pCi/g)
		^{238}Pu	^{239}Pu	^{90}Sr	^{137}Cs	^{95}Zr	^{144}Ce	
1 [a]	0-1		5.8 ± 5%	58 ± 4%	480 ± 6%			2.6 ±16%
	0-24		3.5 ± 5%	88 ± 4%	150 ±13%			2.6 ±16%
2 [a]	0-15	22 ± 2%	34 ± 2%	150 ± 7%	290 ±10%			4.8 ±12%
3 [a]	0-15	15 ± 3%	100 ± 3%	140 ± 4%	220 ±12%			4.6 ±12%
4 [a]	0-15	86 ± 3%	300 ± 3%	100 ± 2%	160 ±14%			3.9 ±14%
5 [a]	0-15	270 ± 4%	860 ± 4%	110 ± 7%	190 ±12%			4.6 ±12%
6 [a]	0-15	2.4 ± 5%	9.5 ± 3%	140 ± 7%	160 ±12%			2.7 ±15%
7 [a]	0-15	4.2 ± 3%	13 ± 3%	100 ± 4%	160 ±12%			3.3 ±12%
8	0-15	1.3 ± 5%	8.6 ± 3%	82 ±13%	160 ±12%			5.0 ±10%
9	0-1		10 ±14%	180 ±13%	280 ± 8%	53 ±20%	140 ±34%	13 ± 5%
	1-5		7.7 ±12%	100 ±20%	360 ± 7%			11 ± 6%
	5-10		3.2 ±35%	100 ±20%	130 ±16%			12 ± 7%
	10-15		2.3 ±20%	55 ±25%				13 ± 6%
	15-20		6.4 ±22%	18 ±25%				3.7 ±14%
10	0-1		6.8 ± 5%	160 ± 3%	360 ± 7%	62 ±17%	140 ± 5%	12 ± 6%
	1-5		5.0 ± 5%	100 ± 3%	190 ±11%			14 ± 5%
	5-10		3.3 ± 7%	100 ± 3%	200 ±13%			11 ± 7%
	10-15		1.4 ±12%	50 ± 3%	61 ±29%			11 ± 7%
	15-20		.73 ±13%	17 ± 5%	33 ±43%			13 ± 6%
11	0-1	1.0 ±32%	9.5 ± 7%	200 ±18%	340 ± 8%	47 ±27%	20 ±33%	11 ± 6%
	1-5	.33 ±59%	8.2 ± 5%	130 ±18%	270 ±10%			9.9 ± 8%
	5-10	.77 ±36%	7.7 ± 7%	60 ±21%	96 ±21%			12 ± 7%
	10-15	.95 ±28%	15 ± 6%	50 ±18%	46 ±35%			12 ± 6%
	15-20	.21 ±99%	4.5 ± 8%	10 ±50%				9.9 ± 8%
12	0-1	.68 ±13%	8.2 ± 4%	160 ± 2%	180 ±16%	70 ±24%	460 ±22%	9.9 ±48%
	1-15	.10 ±40%	2.7 ± 4%	67 ± 2%	63 ±24%			1.9 ±20%
13	0-1	.33 ±25%	5.1 ± 4%	150 ± 2%	230 ±11%	130 ±12%	160 ±48%	3.0 ±15%
	1-15	.10 ±40%	2.5 ± 4%	75 ± 2%	87 ±17%			4.1 ±10%
14	0-1	.73 ±10%	7.1 ± 3%	180 ± 2%	230 ±13%	130 ±14%	570 ±16%	1.9 ±26%
	1-15	.063 ±54%	2.8 ± 5%	75 ± 2%	57 ±25%			2.1 ±18%
15	0-1		12 ± 5%	67 ± 6%	190 ±15%	180 ±13%	590 ±19%	1.2 ±41%
	1-5		5.4 ± 6%	55 ± 5%	95 ±17%			3.9 ±12%
	5-10		2.9 ± 7%	63 ± 4%	88 ±19%			3.5 ±14%
	10-15		2.5 ± 8%	53 ± 5%	89 ±21%			3.0 ±17%
	15-20		1.0 ±10%		30 ±46%			4.4 ±12%
16	0-1		7.1 ± 6%	110 ± 3%	180 ±18%	140 ±21%	320 ±38%	5.1 ±16%
	1-20		1.2 ± 8%	48 ± 4%	34 ±34%			5.6 ± 8%
	20-25		.60 ±20%	24 ± 7%				6.6 ± 9%
17	0-1		11 ± 5%	68 ± 3%	210 ±14%	62 ±23%		3.0 ±19%
	1-20		3.6 ±10%	84 ± 5%	87 ±20%			3.6 ±14%
	20-25		1.6 ±15%	27 ± 6%	29 ±56%	140 ±36%		4.4 ±33%
18	0-1		7.3 ± 5%		150 ±16%			3.5 ±15%
	0-20		2.[illegible] ±10%					
	20-25		.90 ±15%		51 ±32%			5.0 ±11%
19	0-1				190 ±14%	84 ±17%	200 ±47%	5.7 ±11%
	0-20		5.0 ± 5%		88 ±25%			5.0 ±13%
20	0-1				1,400 ± 4%	110 ±14%	200 ±44%	4.0 ±14%
	0-20		3.8 ±10%	71 ± 5%	100 ±17%			3.0 ±15%
21	0-1				510 ± 6%	100 ±14%	300 ±26%	4.1 ±14%
	0-20		2.8 ±15%	52 ± 9%	60 ±26%			3.4 ±14%
22	0-1				1,000 ± 6%	130 ±18%	490 ±25%	3.3 ±23%
	0-20		7.8 ± 5%		190 ±14%			4.6 ±14%
23	0-1				140 ±19%	210 ±37%		4.0 ±16%
	0-20		3.0 ±15%	80 ± 9%	85 ±25%			3.5 ±16%
24	0-1				560 ± 7%	89 ±16%	290 ±30%	4.1 ±15%
	0-20		8.7 ± 5%		97 ±26%			3.7 ±18%
25	0-1				220 ±11%	76 ±15%	200 ±38%	4.4 ±12%
	0-20		1.9 ±20%	70 ± 3%	49 ±28%			3.2 ±13%
26	0-1				180 ±11%	28 ±31%		3.3 ±13%
	0-20		4.4 ±10%		150 ±15%			2.7 ±18%
27	0-1				480 ± 7%	43 ±25%		5.7 ±11%
	0-20		3.4 ±10%		110 ±22%	140 ±35%		3.2 ±18%
28	0-1				290 ±15%	99 ±21%		7.7 ±10%
	0-20		3.1 ±10%		70 ±27%			3.5 ±15%
29	0-1				420 ±12%			4.1 ±20%
	0-20		.12 ± 5%		110 ±18%			3.9 ±14%
30	0-1				730 ± 6%			.89 ±40%
	0-20		5.9 ± 5%	75 ± 5%	94 ±20%			.92 ±40%
31	0-1				210 ±11%			3.5 ±13%
	0-20		3.4 ±15%	37 ±10%	92 ±16%			4.2 ±10%
32	0-1				280 ±10%	140 ±41%		3.9 ±14%
	0-20		2.5 ±15%	38 ± 7%	46 ±30%			4.7 ±10%
33	0-1				410 ± 7%	41 ±25%	200 ±37%	2.6 ±15%
	0-20		1.0 ±10%	66 ± 6%	90 ±18%			3.3 ±13%
34	0-1				92 ±21%	35 ±33%		6.1 ±10%
	0-20		1.1 ±10%	75 ± 3%	100 ±20%			4.2 ±14%
35	0-1				420 ± 7%	77 ±17%		4.3 ±11%
	0-20		6.5 ± 5%	45 ± 7%	160 ±15%			4.7 ±13%
36	0-1				150 ±13%	42 ±28%		5.6 ± 9%
	0-20		3.4 ± 5%	69 ± 6%	75 ±26%			4.8 ±13%
37	0-1				260 ±12%	35 ±46%	220 ±45%	3.0 ±17%
	0-20		4.5 ± 5%	61 ± 6%	95 ±19%			3.3 ±14%
38	0-1				330 ±10%	87 ±30%		6.0 ±11%
	0-20		2.1 ±10%		75 ±28%			5.6 ±12%

See footnotes at end of table.

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Table 5. Activity levels of various radionuclides in soil, January–December 1971—continued

Sampling location	Depth (cm)	Concentration (fCi/g)						^{40}K concentration (pCi/g)
		^{238}Pu	^{239}Pu	^{90}Sr	^{137}Cs	^{95}Zr	^{144}Ce	
39	0–5		12 ± 5%	110 ± 16%	200 ± 13%			11 ± 7%
	5–10		7.3 ± 10%	82 ± 18%	96 ± 21%			13 ± 6%
	10–15		5.5 ± 10%	64 ± 18%	94 ± 24%			9.6 ± 8%
40	0–24		3.5 ± 5%	88 ± 4%				
41	0–1				140 ± 14%	66 ± 34%		
	0–24		200 ± 5%		42 ± 40%			
42	0–1		4.3 ± 10%		130 ± 14%	20 ± 45%		
	0–24		2.5 ± 10%					
43	0–1				480 ± 8%		290 ± 30%	
	0–24		5.5 ± 5%					
44	0–1		3.0 ± 10%					
	0–24		3.2 ± 5%					
45	0–5		360 ± 5%					
	5–10		12 ± 5%					
	10–15		9.0 ± 5%					
	15–25		1.2 ± 5%					
46	0–25		2.6 ± 5%	67 ± 5%				
47	0–25		1.8 ± 6%	61 ± 9%				
48	0–25		2.2 ± 7%	62 ± 6%				
49	0–25		2.5 ± 5%	68 ± 5%				
50	0–25	.18 ± 14%	2.8 ± 4%	92 ± 4%				
51	0–1	1.2 ± 8%	30 ± 4%					
	1–25	2.6 ± 7%	100 ± 3%					
52	0–1	.72 ± 8%	59 ± 8%					
	1–25	3.5 ± 9%	98 ± 5%					
53	0–1	1.8 ± 8%	16 ± 4%					
	1–25	13 ± 4%	220 ± 3%					
54	0–1	1.6 ± 7%	18 ± 4%					
	1–25	14 ± 5%	420 ± 4%					
55	0–30	.14 ± 15%	3.5 ± 4%					
56	0–25	.59 ± 11%	9.3 ± 4%					
57	0–25	.14 ± 15%	2.1 ± 4%					
58	0–25	.23 ± 12%	7.6 ± 3%					
59	0–25	.14 ± 14%	2.6 ± 4%					

[a] Sample locations 1 through 7 are located onsite. All others are offsite.

20–30 cm, while zirconium-95 and cerium-144 could only be detected in the top 1-cm layer.

The resulting deposition values are shown in table 6. Most of the plutonium-239 deposition levels are of the order of 1 mCi/km², but some locations indicate values that are appreciably higher. For instance, the elevated levels shown at onsite locations 1 to 7 are due to their close proximity to the area being used for solar evaporation of low-level radioactive waste liquids. These levels are undoubtedly due to a number of low-level spills that occurred in this area several years ago in connection with the solar evaporation operation. This contamination, however, has not spread offsite as indicated by the plutonium levels observed at loca-

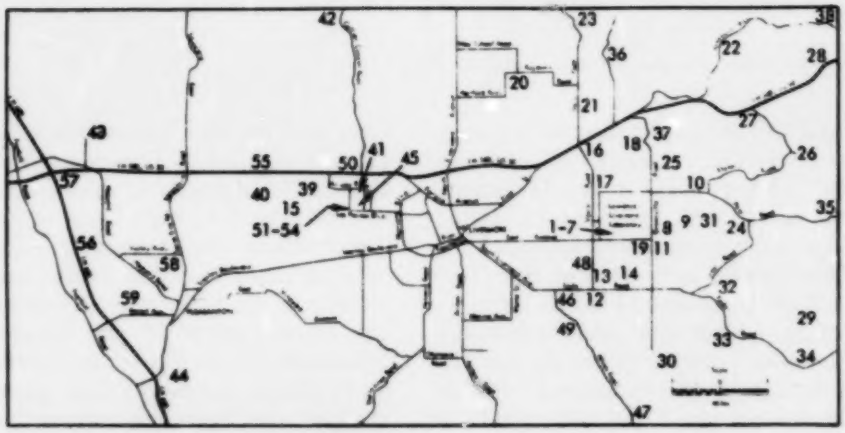

Figure 4. Livermore Valley soil sampling locations

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Table 6. Deposition levels of various radionuclides in soil, Livermore, January–December 1971

Sampling location	Concentration (mCi/km²)					
	^{238}Pu	^{239}Pu	^{90}Sr	^{137}Cs	^{95}Zr	^{144}Ce
1 [a]		1.7	17	36		
2 [a]	4.8	7.5	33	64		
3 [a]	3.4	22	31	49		
4 [a]	18	63	21	34		
5 [a]	56	180	23	39		
6 [a]	0.65	2.6	38	44		
7 [a]	1.2	3.7	29	33		
8	.29	1.9	18	36		
9		1.1	17	15	0.71	1.9
10		.76	20	36	.84	1.9
11	.16	2.6	19	30	.63	.27
12	.028	.65	16	15	.70	4.4
13	.024	.57	17	20	1.5	1.9
14	.018	.65	17	14	1.4	6.3
15		.55	11	20	1.5	5.0
16		.49	18	12	1.9	4.3
17		1.25	26	28		
18		.90				
19		1.4		25	1.1	2.6
20		.93	18	25	1.1	2.0
21		.73	13	15	1.2	3.6
22		1.7		40	1.0	3.9
23		.76	20	21	1.5	2.2
24		2.1		23	.98	3.3
25		.48	18	13	.91	2.3
26		1.14		40	.36	
27		.82		26	.53	
28		.80		19	1.3	
29		3.0		28		
30		1.61	21	26		
31		.97	11	27		
32		.71	11	13		
33		.32	18	23	.51	2.5
34		.26	18	24	.42	
35		1.7	12	42	.97	
36		.89	18	20	.57	
37		1.3	17	27	.42	2.7
38		.57		20	1.1	
39		1.8	18	27		
40		1.1	27			
41		60		12	0.33	
42		0.81				
43		1.9				
44		1.2				
45		27				
46		.91	23			
47		.65	22			
48		.76	22			
49		.87	24			
50		.98	33			
51	0.88	34				
52	1.2	33				
53	4.6	78				
54	5.4	162				
55	.057	1.5				
56	.19	3.0				
57	.044	.68				
58	.079	2.7				
59	.047	.9				

[a] Sample locations 1 through 7 are onsite. All others are offsite.

tions 8, 9, and 11 which are situated immediately offsite from the contaminated area. In addition, the holding pond at the Livermore Sewage Treatment Plant, locations 41, 45, 51 through 54 also indicate elevated plutonium-239 activities. These values have resulted from routine and accidental releases of small amounts of plutonium over long time periods through the sanitary sewer system which carries the laboratory's biological and industrial effluents to the Livermore Sewage Treatment Plant.

In order to gain a better perspective of the contribution that the laboratory operations have had on the environmental levels of plutonium within the Livermore Valley, the plutonium-239 deposition values were plotted in figure 5. The data were found to fit two separate distributions. The upper distribution represents data obtained from the onsite locations in the vicinity of the solar evaporation area and from the holding pond at the Livermore Sewage Treatment Plant. The lower distribution, on the other hand, represents the remainder of the data obtained from areas where the laboratory's contribution has been minimal, if any, and therefore represents predominantly the contri-

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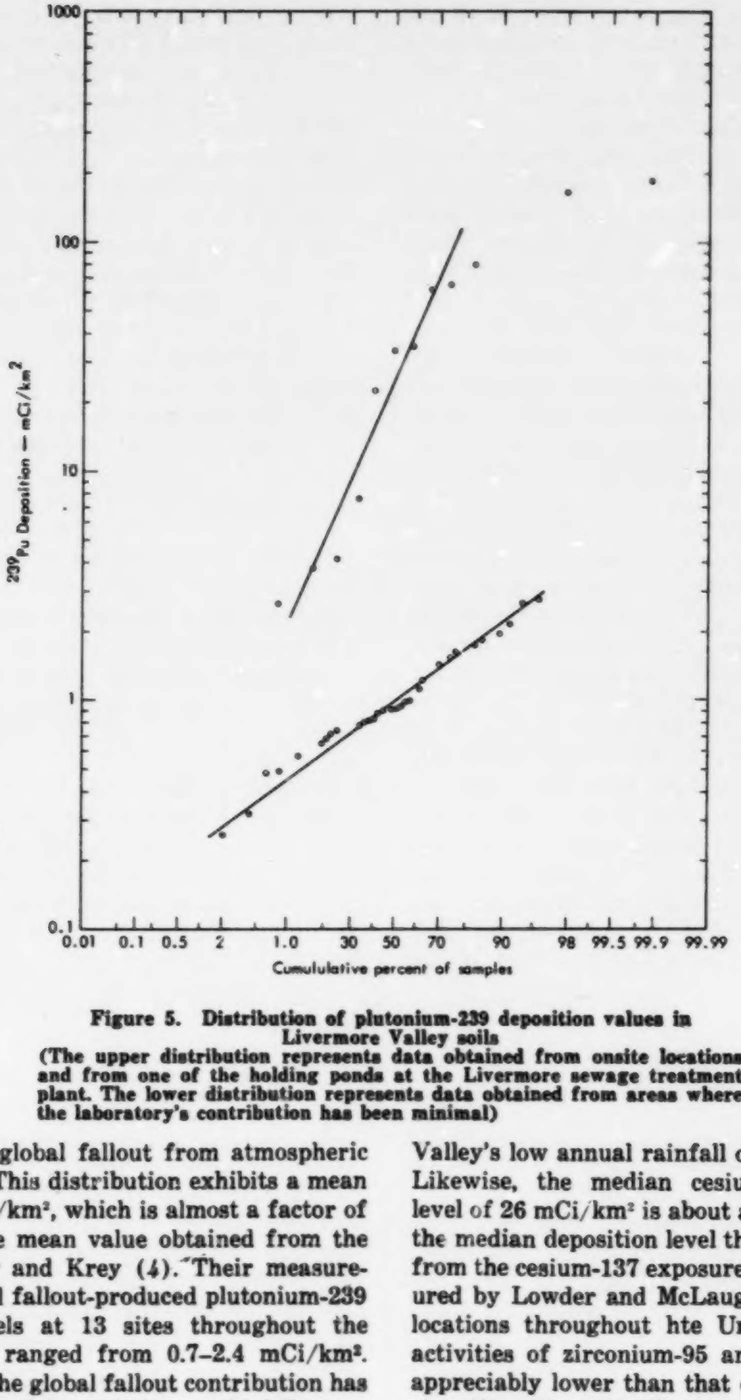

Figure 5. Distribution of plutonium-239 deposition values in Livermore Valley soils
(The upper distribution represents data obtained from onsite locations and from one of the holding ponds at the Livermore sewage treatment plant. The lower distribution represents data obtained from areas where the laboratory's contribution has been minimal)

bution due to global fallout from atmospheric weapons test. This distribution exhibits a mean value of 1 mCi/km^2, which is almost a factor of 2 less than the mean value obtained from the data of Hardy and Krey (*4*). Their measurements of global fallout-produced plutonium-239 deposition levels at 13 sites throughout the United States ranged from 0.7–2.4 mCi/km^2. Since most of the global fallout contribution has been by wet deposition, this factor of 2 difference is quite reasonable in view of the Livermore Valley's low annual rainfall of about 14 inches. Likewise, the median cesium-137 deposition level of 26 mCi/km^2 is about a factor of 3 below the median deposition level that one may derive from the cesium-137 exposure rates in air measured by Lowder and McLaughlin (*5*) at many locations throughout hte United States. The activities of zirconium-95 and cerium-144 are appreciably lower than that of cesium-137 and strontium-90 primarily due to their relatively short half-lives. One would expect their activities to be mainly due to the recent French and Chinese atmospheric nuclear weapons tests. Thus, the laboratory's contribution to these fission product activities is negligible.

The samples collected onsite in the vicinity of the area being used for solar evaporation of low level radioactive liquids were, in addition, subjected to isotopic uranium analysis by mass spectrographic methods. The results are shown in table 7. The total uranium concentrations are less than the global average of about 4 µg/g and the uranium-235/uranium-238 ratio approximates that in natural uranium, indicating that the solar evaporation operation has not contributed any measurable uranium activity to the environment in this particular area.

Environmental radiation levels due to the gamma-emitting radionuclides distributed in the soil may be inferred from these measurements by using the data of Beck and de Planque (*6*). Detailed calculations have not been completed at this time, but preliminary results indicate that the mean exposure rate in air due to the cesium-137 activity in the soil at a height of 1 meter above the ground within the Livermore Valley is approximately 0.1 µR/h (0.88 mR/yr). The exposure rates due to the zirconium-95 and cerium-144 activities in the soil are insignificant relative to that of cesium-137. By using the data of Wollenberg, et al (*7*) and the data in tables 5 and 7, one may determine the mean natural background exposure rates due to the activities of potassium-40 and uranium-238 series in the soil to be 0.7 µR/h (6.2 mR/yr) and 1.4 µR/h (12.3 mR/yr), respectively, at a height of 1 meter above the ground. Thus, the natural contribution to the exposure rate due to gamma emitters in the soil is far greater than that due to the artificially produced radionuclides. To determine the environmental impact due to the elevated plutonium deposition levels is very difficult. For these particular sites, the primary concern to man is that due to resuspension of the plutonium and subsequent inhalation. Since resuspension factors vary over many orders of magnitude, it is difficult to calculate a meaningful expected airborne concentration. However, we anticipate that these airborne concentrations will not be significantly above background levels.

Sewer effluent

The low level radioactive wastes from the laboratory are discharged into the City of Livermore sanitary sewer system. This effluent is processed at the Livermore Sewage Treatment Plant where the liquid and sludge are separated on entering the plant. The sludge passes into one of two digesters where it is broken down by bacterial action. Methane gas is evolved and burned, and the remaining sludge is released to large sludge ponds and retained for subsequent use as a soil conditioner. The purified water is used for irrigating the Livermore Golf Course and nearby agricultural land; the excess is discharged into the Los Positas Arroyo.

Table 7. Concentrations of uranium in soils, Livermore Laboratory, January–December 1971

Sampling location	Depth (cm)	^{234}U g/g)	^{235}U (ng/g)	^{238}U (µg/g)	Total uranium (µg/g)	^{235}U/^{238}U ª
2	0–15	114 ± 4%	13.4 ±1%	1.86 ±2%	1.87 ±2%	0.0072
3	0–15	115 ± 5%	13.5 ±1%	1.88 ±2%	1.90 ±2%	.0072
4	0–15	110 ± 3%	13.6 ±1%	1.88 ±2%	1.90 ±2%	.0072
5	0–15	150 ± 1%	14.8 ±1%	2.05 ±2%	2.07 ±2%	.0072
6	0–15	114 ± 9%	12.0 ±2%	1.69 ±2%	1.70 ±2%	.0071
7	0–15	100 ± 2%	12.5 ±2%	1.75 ±2%	1.76 ±2%	.0071
8	0–15	108 ± 2%	12.1 ±1%	1.69 ±2%	1.71 ±2%	.0072
11	0–1	72.5 ± 1%	9.70 ±1%	1.36 ±2%	1.37 ±2%	.0071
	1–5	85.0 ± 1%	11.2 ±1%	1.55 ±2%	1.56 ±2%	.0072
	5–10	70.0 ±14%	8.80 ±1%	1.22 ±2%	1.23 ±2%	.0072
	10–15	80.0 ± 3%	10.6 ±1%	1.48 ±1%	1.49 ±2%	.0072
	15–20	81.0 ± 4%	11.0 ±4%	1.53 ±2%	1.54 ±2%	.0072

ª The ^{235}U/^{238}U ratio in natural uranium is 0.0072.

Table 8. Livermore sewage treatment plant sampling results, January–December 1971

Month (1971)	Gross alpha activity (pCi/liter)						
	Digesters		Aeration tank		Effluent		
	High	Average	High	Average	High	Average	Percent AEC standard [a]
January	380 ±20%	250	57 ±19%	43	22 ±50%	13	13
February	230 ±24%	160	29 ±26%	27	80 ±50%	26	26
March	180 ±42%	150	49 ±41%	39	32 ±50%	14	14
April	190 ±23%	190	31 ±27%	29	11 ±50%	54	54
May	350 ±20%	210	74 ±22%	49	27 ±50%	11	11
June	510 ±13%	280	52 ±21%	48	5.6 ±50%	2.7	2.7
July	300 ±16%	220	320 ±13%	140	7.4 ±50%	3.3	3.3
August	440 ±19%	260	73 ±19%	45	13 ±50%	5.9	5.9
September	530 ±24%	280	99 ±15%	61	13 ±50%	5.3	5.3
October	220 ±21%	110	66 ±17%	50	11 ±50%	5.9	5.9
November	440 ±21%	220	42 ±26%	30	14 ±50%	8.2	8.2
December	260 ±22%	180	80 ±18%	47	11 ±50%	6.5	6.5
Average		208		51		13	13
	Gross beta activity (pCi/liter)						
January	1,400 ±5%	530	60 ±4%	49	48 ±15%	17	17
February	970 ±4%	360	45 ±5%	27	37 ±80%	19	19
March	1,100 ±6%	580	120 ±5%	71	88 ±14%	35	35
April	1,000 ±4%	530	84 ±5%	48	40 ± 9%	17	17
May	340 ±8%	280	52 ±5%	37	31 ±17%	17	17
June	1,000 ±4%	390	41 ±5%	36	17 ±24%	15	15
July	400 ±7%	290	55 ±4%	36	19 ±22%	14	14
August	600 ±7%	380	76 ±4%	52	19 ±22%	14	14
September	4,300 ±2%	1,000	55 ±4%	47	20 ±20%	15	15
October	420 ±8%	250	48 ±5%	43	44 ±13%	19	19
November	400 ±8%	280	38 ±6%	35	24 ±19%	17	17
December	1,000 ±4%	380	58 ±4%	48	43 ±13%	22	22
Annual average		440		44		18	18

	Tritium activity (nCi/liter)			Strontium-90 activity (pCi/liter)	
	Effluent			Effluent	
	High	Average	Percent AEC standard [c]	Average	Percent AEC standard [d]
January	14 ± 5%	11	0.37	0.5 ±50%	0.17
February	4.1 ±50%	3.6	.12	1.5 ±20%	.50
March	240 ± 3%	43	1.43	.6 ±21%	.20
April	8.0 ±14%	4.2	.14	1.6 ±18%	.20
May	340 ± 2%	56	1.87	.4 ±50%	.13
June	1.8 ±50%	1.7	.06	.6 ±50%	.20
July	15 ± 5%	6.3	.21	.5 ±50%	.17
August	3.9 ±16%	2.2	.07	2.3 ±50%	.77
September	110 ± %	15	.50	1.3 ±25%	.43
October	20 ± 4%	5.8	.19	1.1 ±38%	.37
November	12 ± 6%	3.5	.12	3.3 ±30%	1.10
December	12 ± 6%	3.9	.13	.9 ±21%	.30
Annual average		13	.43	1.2 ±42%	

[a] AEC standard (alpha activity) = 100 pCi/liter.
[b] AEC standard (beta activity) = 100 pCi/liter.
[c] AEC standard (HTO) = 3,000 nCi/liter.
[d] AEC standard (^{90}Sr) = 300 pCi/liter.

Weekly samples were collected from each digester, the aeration tank and the liquid effluent discharged from the plant in order to determine if any significant buildup of radioactivity occurred within the plant. These samples were subjected to gross alpha and beta analyses by complete dissolution, electrolytic deposition and direct proportional counting. The tritium analyses were performed by subjecting 1 ml of each sample to direct liquid scintillation counting. In addition, a monthly composite sample of the effluent was analyzed for strontium-90 by radiochemical separation and beta counting. The concentrations observed during 1971 averaged over 1 month periods are given in table 8. Most of the gross alpha and gross beta activities are associated with the sludge present in the effluent. Thus, samples obtained from the digesters show the highest activities with the expected attendant decrease in activity as the relatively purified liquid passes through the aeration tank and is finally released from the plant.

Water

Monthly samples were collected from various water sources in the Livermore Valley. These samples were analyzed for gross alpha and gross beta activities by techniques similar to those used for sewage effluent samples. No sample showed an alpha activity above the limit of detection of 1.2 pCi/liter. Quarterly averages for beta activities are given in table 9. Locations 7, 14 through 18, and 21 through 24 represent surface sources such as ponds, creeks, reservoirs, and aqueducts. Livermore rainfall is sampled at location 20. The remainder of the locations are domestic water sources. The activities are reasonably homogeneous with the highest value occurring in the rainfall sample collected over a 3-month period.

The samples collected during the first 6 months of 1971 were analyzed for tritium activity by direct scintillation counting. The maximum activity was 11 nCi/liter ± 8 percent with an average value of 4.0 nCi/liter (the limit of detection) which is 0.1 percent of the offsite AEC standard of 3 μCi/liter. Because of these low radioactivities, the samples collected during the last 6 months were vacuum distilled and electrolytically enriched before scintillation counting. The results of these analyses are shown in table 10. Inspection of the data indicates that the samples also exhibit rather uniform tritium concentrations that are well below the AEC standards. The table also includes an estimate of the dose that may be delivered to an adult consuming water containing the listed tritium concentrations. The doses, which are typically less than 0.1 mrem, are based upon a daily water consumption of 1 liter per day (*8*) and the model of Anspaugh, *et al.* (*9*).

Vegetation

Vegetation samples (usually native grasses) were collected from nine locations in the Livermore Valley during January, April, and May. The samples were dried in ambient air for about a week and then pressed into 5-inch diameter and 1-inch thick pellets weighing approximately 200 grams. The pellets were analyzed for various gamma-emitting radionuclides by placing them between two 8- by 4-inch NaI(Tl)crystals. A portion of each sample was also freeze dried and the collected water was analyzed for tritium activity by direct scintillation counting. These techniques were changed in the middle of the year after the development of improved analytical facilities. During the months of August, October, and

Table 9. Gross beta radioactivity in Livermore water samples, January–December 1971

January-March		April-June		July-September		October-December	
Location	Activity (pCi/liter)	Location	Activity (pCi/liter)	Location	Activity (pCi/liter)	Location	Activity (pCi/liter)
1	—	11	7.4	11	3.7	11	3.0
2	—	12	3.9	12	3.3	12	2.0
3	2.9	13	3.2	13	3.4	13	2.0
4	2.2	14	7.0	14	—	14	—
5	2.7	15	4.9	15	2.3	15	2.9
6	2.0	16	12.3	16	7.1	16	5.9
7	3.1	17	4.9	17	6.0	17	5.2
8	2.4	18	9.2	18	3.7	18	3.1
9	2.6	19	3.4	19	2.1	19	2.9
10	—	20	23.7	20	—	20	—
11	—	21	4.7	21	2.0	21	3.0
12	4.3	22	9.1	22	8.2	22	7.6
13	3.6			23	2.2	23	2.4
				24	4.8	24	6.1
Average	2.9		7.8		4.0		3.8
Percent AEC standard[a]	10		26		13		13

[a] AEC standard (beta activity) = 30 pCi/liter.

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Table 10. Tritium activities in Livermore water samples collected during July–December 1971

Sampling location	Concentration (pCi/liter)		Percent AEC standard[a]	Calculated annual adult whole body radiation dose (mrem)
	Maximum	Average		
11	320 ±6%	280	0.0086	0.010
15	320 ±7%	280	.0093	.011
16	1,100 ±4%	870	.029	.035
17	210 ±8%	[b]200	.0067	.0080
18	—	[b]270	.0090	.011
19	170 ±8%	[b]160	.0053	.0065
20	—	[b]810	.027	.032
21	—	[b]270	.0090	.011
22	410 ±6%	[b]400	.013	.016
23	720 ±5%	[b]370	.012	.015
24	1,200 ±4%	[b]600	.020	.024
Average		410	0.014	0.016

[a] AEC standard (HTO) = 3×10^6 pCi/liter.
[b] Single sample collected at these locations.

November, samples were collected from 13 locations in the Livermore Valley. The samples collected during a particular month were dried and composited. A 100-gram portion of the composite sample was counted on the Ge(Li) detector used for analyzing the airborne particulate samples. The tritium concentrations in the water, obtained by freeze drying these samples, were determined by electrolytic enrichment and subsequent scintillation counting.

The results of the gamma spectral analyses are shown in table 11. These activities exhibit their highest values during the spring months; this is undoubtedly due to the higher ambient atmospheric concentrations during this time of year. Using these data, one may calculate the annual radiation dose received by man from direct ingestion of these radionuclides assuming the observed activities are typical of those in edible vegetation. The calculated adult whole body or critical organ doses due to the gamma emitters shown in table 11, are based upon an adult consumption of 400 grams per day vegetation (*8*) with a moisture content of 80 percent and the data of Ng, *et al.* (*10*) regarding the dose received per unit of radioactivity consumed under equilibrium conditions. With the exception of global fallout-produced cerium-144 and natural potassium-40 activities, these radionuclides deliver appreciably less than 1 mrem/yr to the whole body or critical organ as a result of direct ingestion of edible vegetation. The cerium-144 and potassium-40 activities, on the other hand, may easily deliver up to 10 mrem/yr to the lower large intestine and whole body, respectively.

The results of the tritium analyses are shown in tables 11 and 12. The data show significant variation from one location to another which may be caused by laboratory operations.

From figure 2, one may expect the effect of the laboratory's operation on the environment to be minimal at locations 4, 7, 13, 17, 18, and 19 because the prevailing wind is from the southwest. Samples collected at these locations exhibit tritium values ranging from 160 to 450 pCi/liter, which may be considered environmental background levels. However, locations 10 and 11 are onsite and locations 5, 15, 16, and 20, which show elevated levels, are situated in a generally downwind direction from the laboratory, thus exposing the vegetation in these areas to the low level gaseous effluent released routinely from the Gaseous Chemistry Building. The samples collected at location 12 represent grass that has been watered by the liquid effluent from the Livermore Sewage Treatment Plant. The resulting whole body doses to an adult, shown in the tables, were derived from the model of Anspaugh, *et al.* (*9*). These are also based upon the direct daily consumption of 400 grams of vegetation (*8*). This mass of vegetation, however, is assumed to be equivalent to the same mass of water containing the tritium concentrations shown in the tables under equilibrium conditions. One may readily observe that, in spite of the slightly elevated levels, the calculated annual whole body doses are still very small.

Milk

During the first 8 months of 1971, milk samples were collected each month from two dairies, one located in the Livermore Valley about 6 miles west of the laboratory and the other in the San Joaquin Valley about 6 miles southwest of Tracy. In August 1971, the Livermore Valley dairy ceased operations. Since no other was available, milk sampling was restricted to the San Joaquin Valley dairy during the rest of the year. Before analysis, the samples were concentrated by means of a vacuum-operated, foam-entrainment evaporator so that about 9

Table 11. Average radionuclide activities in Livermore vegetation samples collected during 1971

Radioactivity in samples collected	Average activity (pCi/g)	Calculated annual dose ingestion (mrem)	Critical organ
During Jan., Apr. and May:			
^{137}Cs	0.18	0.32	Whole body
^{144}Ce	1.4	11.0	Lower large intestine
^{95}Zr–^{95}Nb	.63	—	
^{7}Be	1.8	.090	Lower large intestine
^{3}H	25 nCi/l	.40	Whole body
During Aug., Oct. and Nov:			
^{137}Cs	.08	.14	Whole body
^{106}Ru	.13	.14	Lower large intestine
^{144}Ce	.59	4.6	Lower large intestine
^{95}Zr	.053	.12	Lower large intestine
^{7}Be	2.1	.10	Lower large intestine
^{40}K	3.0	4.2	Whole body

Table 12. Tritium activities in Livermore vegetation samples collected in August, October, and November 1971

Sample location [a]	Tritium activities (nCi/liter)		Calculated annual whole body dose (mrem)
	Maximum	Average	
4	0.46 ±51%	0.33	0.005
5	9.8 ± 3%	4.7	.08
7	.61 ±31%	.45	.007
10	28 ± 2%	11	.2
11	120 ± 1%	39	.6
12	3.3 ± 7%	1.8	.03
13	.44 ±44%	.30	.005
15	1.7 ±12%	1.4	.02
16	9.0 ± 4%	3.5	.06
17	.17 ±103%	.16	.003
18	.28 ±65%	.28	.005
19	.26 ±68%	.22	.003
20	6.8 ± 4%	6.4	.1
Average		5.3	0.08

[a] The sample locations are shown in figure 1.

liters of whole milk were condensed to 2 liters. The resulting samples were subjected to gamma spectral analyses by inserting them between two 8- by 4-inch NaI (Tl) crystals. In addition, each sample was analyzed for tritium activity by counting 1 milliliter of the distillate directly in a standard liquid scintillation detector. The activities of cesium-137, cerium-144, tritium, and potassium-40 are shown in table 13. Also shown are the calculated annual adult whole body or critical organ doses delivered to man via the milk pathway. These calculations are based upon a daily intake of 260 g/day (*8*) and the models previously referenced. As expected, the only significant dose to an individual is that from potassium-40.

Accidental release of tritium gas

Continuous air sampling is maintained on the stack effluent from the Gaseous Chemistry Building. On April 12, 1971, an accidental release of 240 Ci of tritium occurred. Because the tritium was expected to be in the vapor

Table 13. Radionuclide activity observed in milk samples collected January–December 1971

Location, date collected, and radionuclide	Concentration (pCi/liter)		Calculated annual adult radiation dose (mrem)	Critical organ
	Maximum	Average		
Livermore Valley Dairy				
January–August:				
Cesium-137	[illegible]	4.5	0.026	Whole body
Cerium-144	19	11	.28	Lower large intestine
Tritium	100,000	17,000	.054	Whole body
San Joaquin Valley Dairy				
January–August:				
Cesium-137	5.6	3.8	.022	Whole body
Cerium-144	53	13	.14	Lower large intestine
Tritium	6,700	430	.0013	Whole body
September–December:				
Cesium-137	3.9	2.7	.016	Whole body
Cerium-144	26	18	.46	Lower large intestine
Tritium	1,300	620	.0019	Whole body
Potassium-40	1,300	1,200	5.4	Whole body

form, an extensive sampling program was conducted to evaluate the impact of the release on the environment. Vegetation, atmospheric water vapor, and water samples were collected and analyzed for tritium activity. The vegetation samples were freeze-dried and the collected water was subjected to scintillation counting. Other samples were counted directly in the same manner. Detectable activities were observed in some offsite vegetation and water vapor samples. The maximum activity in vegetation samples was 160 nCi/liter with the average activity of all the samples being $\leq$ 25 nCi/liter. The atmospheric water vapor samples indicated a maximum activity of 5.9 nCi/m^3 and an average value of 2 nCi/m^3.

A hazards analysis was performed in order to determine the potential exposure to a hypothetical individual standing downwind at the point of maximum surface air concentration during cloud passage. Using standard atmospheric diffusion calculations and tritium uptake estimates, one may calculate that it would have been possible for this individual to have received a maximum of 1.5 mrem during cloud passage. An estimate was also made of the maximum potential dose that a child could have received from drinking milk produced by cows grazing on vegetation contaminated with tritium at the maximum observed concentration. Using the model of Anspaugh, *et al.* (*9*), the maximum potential dose via this pathway to an infant would have been 0.18 mrem and that to an adult, 0.03 mrem.

Environmental radiation measurements

Environmental radiation background measurements were made at 12 laboratory perimeter locations shown in figure 2, and at 40 offsite locations in the immediate vicinity of the laboratory. These measurements were made with CaF:Dy (TLD-200) thermoluminescent dosimeters placed at a height of 1 meter above the ground. Exposure periods were usually 3 months. The resulting exposure rates reflect the sum of terrestrial and cosmic radiation sources. Based on past experience, the exposure rates in the Livermore Valley due to terrestrial sources varied between 4 and 7 μR/h depending upon the location, while that due to cosmic radiation, according to the data of Lowder and Beck (*11*), is approximately 4 μR/h. Table 14 shows the exposure rates obtained at the perimeter locations during three periods in 1971. This data is also expressed as projected annual millirem dose rates (1 μR/h = 7.612 mrem per year). Inspection of the data revealed that location 5 during the April–June period and locations 13, 14, and 15 during the November–December period showed above average exposure rates. Location 5 is adjacent to a cyclotron building and locations 13, 14, and 15 are near a linear accelerator facility.

Site 300

Atmospheric radioactivity

The concentrations of various particulate airborne radioactive substances were measured

Table 14. Environmental radiation background measurements at the Livermore Laboratory perimeter, 1971

Location	April-June		August-November		November-December	
	(μR/h)	(mrem/year)	(μR/h)	(mrem/year)	(μR/h)	(mrem/year)
1	10.3	78	9.1	69	11.1	85
2	9.6	73	9.4	72	11.9	91
3	11.1	85	10.4	79	11.7	88
4	9.6	73	9.5	72	11.1	85
5	14.4	110	10.4	79	8.9	68
6	9.6	73	—	—	9.3	71
7	7.9	60	8.7	66	—	—
8	8.8	67	8.0	61	9.5	72
9	7.9	60	8.1	62	9.5	72
13	—	—	10.5	80	12.1	92
14	—	—	9.1	69	12.3	94
15	—	—	11.3	86	13.2	100
Average	9.9	75	9.5	72	11.0	84

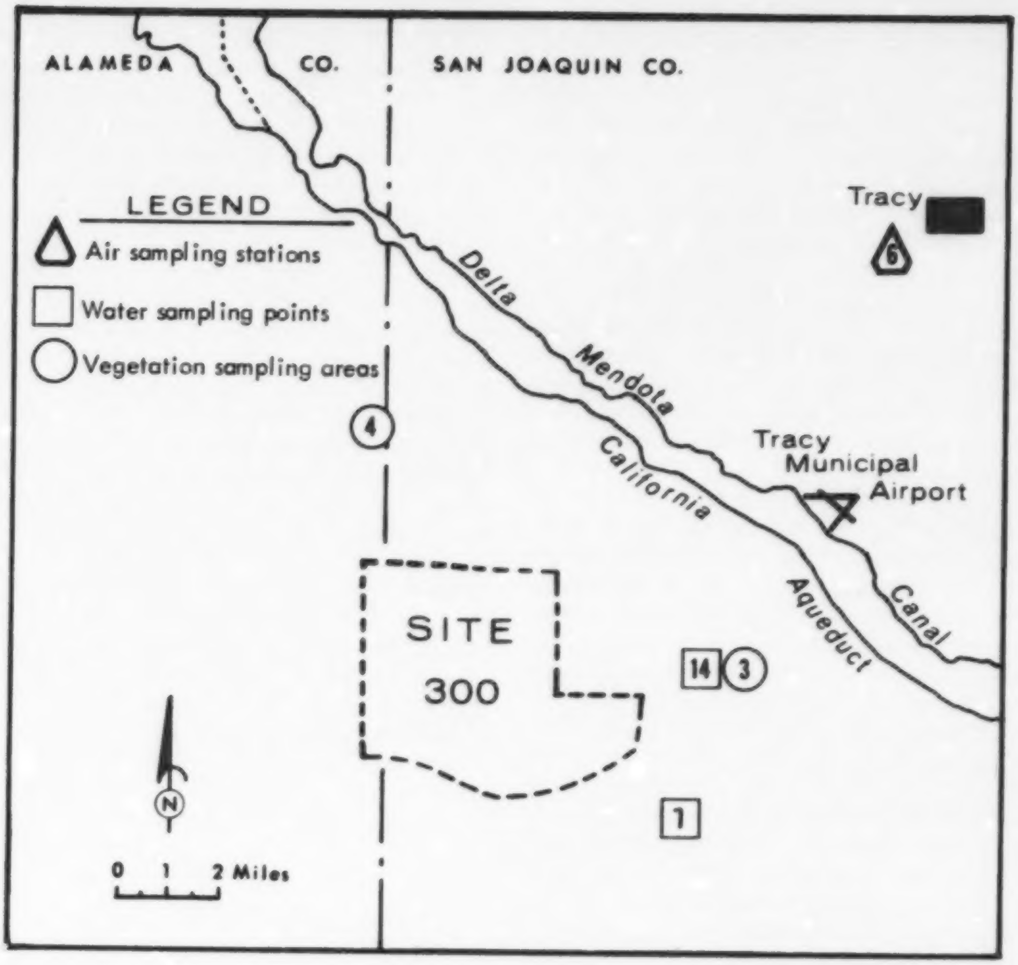
ALAMEDA CO.
SAN JOAQUIN CO.
LEGEND
Air sampling stations
Water sampling points
Vegetation sampling areas
Tracy
6
Delta Mendota Canal
California Aqueduct
Tracy Municipal Airport
4
SITE 300
14
3
1
N
0 1 2 Miles

Figure 6. Air, water, and vegetation sampling locations in the Site 300 area (See figure 7 for sampling locations inside Site 300 boundary)

continuously at 11 air sampling locations as shown in figures 6 and 7. Ten of the samplers are located within the boundaries of Site 300, and the 11th is located in Tracy, the primary population center of concern. The onsite samples are collected on 8- by 10-inch Whatman-41 filters at a flow rate of about 25 cfm. Samples in Tracy are collected on 4- by 9-inch HV70 (cellulose-asbestos) filters at a flow rate of about 4 cfm. Filters are changed weekly during the winter months and twice weekly during the summer to avoid excessive mass loading. The filters are analyzed by the method previously described for filters used in the Livermore Valley.

No gross alpha radioactivity above the 1 fCi/m^3 detection limit was observed on these filters. The gross beta activities, averaged over 3-month periods, are listed in table 15 for each sampling location. These average radioactivities are slightly higher than those measured in the Livermore Valley. Gamma spectral measurements made on monthly composite samples of the filters collected onsite reveal measurable quantities of various gamma-emitting radionuclides as may be seen in table 16. These activ-

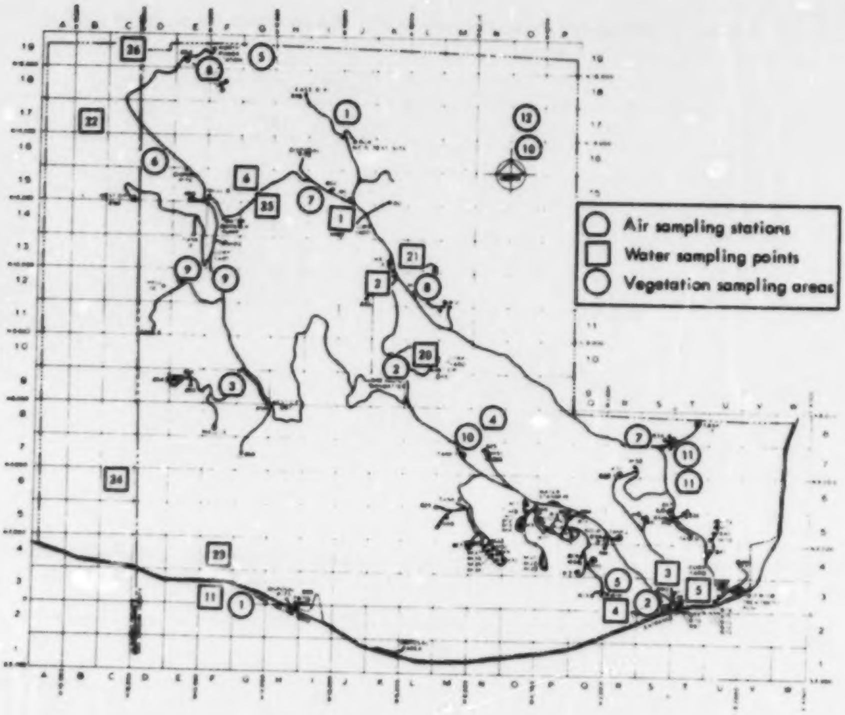

Figure 7. Air, water, and vegetation sampling locations inside Site 300 boundary

Table 15. Airborne particulate activity at Site 300, January–December 1971

Sampling location [a]	Activity concentration (pCi/m³)									Percent of AEC standard [b]
	January-March		April-June		July-September		October-December		Annual average	
	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average		
1	0.42 ±1%	0.090	0.33 ±1%	0.26	0.34 ±1%	0.20	0.13 ±6%	0.057	0.15	15
2	.40 ±1%	.095	.34 ±1%	.22	.43 ±1%	.21	.12 ±5%	.054	.14	14
3	.33 ±1%	.086	.29 ±1%	.20	.40 ±1%	.19	.11 ±6%	.051	.13	13
4	.18 ±2%	.065	.30 ±1%	.23	.42 ±1%	.21	.30 ±6%	.079	.15	15
5	.43 ±1%	.090	.27 ±1%	.20	.60 ±2%	.19	.075 ±7%	.041	.13	13
6	.42 ±2%	.12	.31 ±2%	.23	.40 ±2%	.16	.12 ±8%	.065	.14	14
7	.38 ±1%	.089	.32 ±1%	.21	.41 ±1%	.19	.082 ±6%	.046	.13	13
8	.27 ±1%	.077	.29 ±1%	.24	.49 ±1%	.27	.20 ±7%	.12	.18	18
9	.65 ±1%	.13	.45 ±1%	.33	.82 ±1%	.28	.14 ±4%	.061	.20	20
10	.44 ±1%	.11	.39 ±1%	.29	.46 ±1%	.23	.13 ±5%	.096	.18	18
11	.28 ±1%	.10	.61 ±1%	.37	.83 ±1%	.26	.12 ±7%	.059	.20	20

[a] See figure 3.
[b] The AEC standard is 1 pCi/m³.

ity levels are essentially identical with those measured in the Livermore Valley and may readily be accounted for as being due to global fallout. The results of isotopic plutonium and uranium analyses, performed by the techniques described previously, are provided in table 17. The relative abundance of plutonium-238 to plutonium-239 is approximately that expected in global fallout. The uranium content of airborne debris, on the other hand, is appreciably depleted in uranium-235 relative to that of natural uranium and the concentrations of ura-

Table 16. Results of gamma-ray measurements of Site 300 air filters, January–December 1971

Month (1971)	Concentration (fCi/m³)							
	^{144}Ce	^{141}Ce	^{125}Sb	^{7}Be	^{103}Ru	^{106}Ru	^{137}Cs	^{95}Zr
January	8.8 ± 2%	2.0 ± 7%	0.64 ±12%	41 ±3%	2.2 ± 7%	4.0 ±12%	0.97 ±5%	2.8 ±3%
February	15 ± 2%	4.6 ± 4%	1.1 ±14%	47 ±4%	6.4 ± 4%	4.4 ±19%	1.4 ±7%	7.4 ±2%
March	47 ± 1%	18 ± 2%	2.6 ±10%	89 ±3%	26 ± 2%	18 ± 8%	3.9 ±4%	33 ±1%
April	46 ± 1%	11 ± 2%	2.2 ± 2%	61 ±4%	19 ± 3%	9.5 ±10%	3.3 ±6%	33 ±1%
May	120 ± 1%	16 ± 7%	6.8 ± 7%	120 ±3%	33 ± 2%	50 ± 5%	8.8 ±3%	7.1 ±1%
June	87 ±13%	9.4 ± 3%	4.7 ±13%	70 ±5%	18 ± 3%	40 ± 9%	5.5 ±6%	47 ±1%
July	140 ± 1%	8.1 ± 7%	8.1 ± 5%	200 ±3%	19 ± 4%	59 ± 4%	9.7 ±3%	64 ±1%
August	91 ± 1%	2.9 ± 9%	5.4 ± 7%	150 ±2%	6.4 ± 6%	40 ± 6%	6.7 ±4%	81 ±1%
September	59 ± 1%	1.9 ±15%	3.4 ±10%	200 ±2%	3.5 ±10%	29 ± 7%	4.7 ±5%	15 ±2%
October	26 ± 2%	.75 ±30%	1.4 ±22%	150 ±3%	1.0 ±25%	9.4 ± 9%	1.9 ±9%	5.0 ±4%
November	34 ± 2%	.27 ±76%	2.4 ±17%	220 ±2%	.64 ±39%	13 ±16%	2.8 ±8%	5.6 ±4%
December	18 ± 3%	16 ± 2%	1.8 ±16%	130 ±3%	21 ± 2%	10 ±16%	1.8 ±8%	2.8 ±5%
Annual average	58	7.6	3.3	120	13	24	4.3	21
RCG [a]	200,000	5,000,000	900,000	40,000,000	3,000,000	200,000	500,000	1,000,000
Percent of AEC standard	0.029	0.00015	0.00037	0.00030	0.00043	0.012	0.00086	0.0021

[a] Assumes the activity is in an insoluble form.

Table 17. Plutonium and uranium concentrations in Site 300 air samples, January–December 1971

Month (1971)	Activity (aCi/m³)		^{238}Pu/^{239}Pu	Mass (pg/m³)		^{235}U/^{238}U
	^{238}Pu	^{239}Pu		^{235}U	^{238}U	
January	3.5 ± 6%	27 ±3%	0.13	1.8 ±2%	9,300 ±2%	0.00020
February	3.8 ± 6%	31 ±3%	.12	.15 ±2%	54 ±2%	.0028
March	8.2 ± 7%	95 ±4%	.086	.34 ±1%	83 ± %	.0041
April	4.8 ± 6%	67 ±4%	.072	1.9 ±1%	900 ±1%	.0021
May	4.5 ± 7%	74 ±4%	.061	.25 ±4%	65 ±4%	.0038
June	4.4 ±10%	83 ±5%	.053	.41 ±2%	180 ±2%	.0023
July	3.1 ±10%	110 ±3%	.028	.72 ±2%	250 ±2%	.0029
August	1.6 ±15%	70 ±6%	.023	.39 ±1%	98 ±2%	.0040
September	2.8 ± 6%	54 ±3%	.052	.27 ±1%	49 ±1%	.0055
October	1.2 ±12%	35 ±4%	.034	.31 ±1%	80 ±1%	.0038
November	1.9 ± 6%	26 ±3%	.073	.28 ±1%	44 ±2%	.0064
December	.82 ± 9%	14 ±4%	.058	.096 ±1%	27 ±2%	.0036
Annual average	3.4	57		.58	930	
AEC standard [a]	1,000,000	1,000,000		1,900,000	15,000,000	
Percent AEC standard	0.00034	0.0057		0.000031	0.0062	

[a] Assumes the activity is in an insoluble form.

nium are at times significantly greater than those measured in the Livermore Valley. This is not unexpected in view of the sizeable quantities of depleted uranium that have been expended over the years as a result of the high explosive detonations at the site. However, these concentrations are nevertheless far lower than the current concentration guide levels.

The calculated annual lung doses to an adult resulting from inhalation of the radionuclides listed in tables 16 and 17 are shown in table 18. These were derived in a manner similar to that used to obtain the values in table 4. Again, these inhalation doses are extremely small with the greatest contribution being due to cerium-144.

Table 18. Inhalation doses resulting from the air concentrations shown in tables 16 and 17

Radionuclide	Calculated annual lung dose (mrem)
Cerium-144	2.4
Cerium-141	.050
Antimony-125	.032
Beryllium-7	.076
Ruthenium-103	.13
Ruthenium-106	.40
Cesium-137	.068
Zirconium-95	.44
Plutonium-238	.0074
Plutonium-239	.12
Uranium-235	.0024
Uranium-238	.56

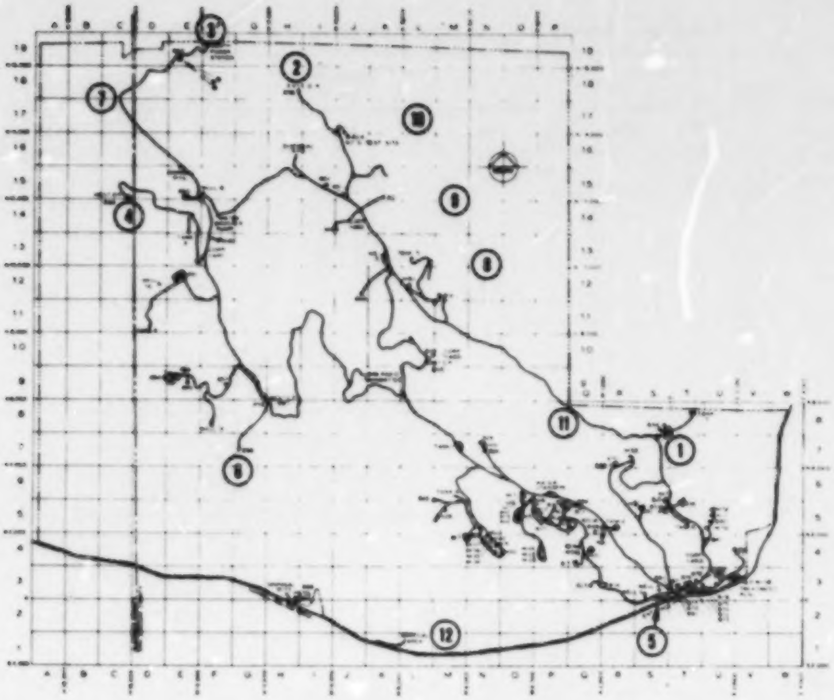

Figure 8. Site 300 soil sampling locations

Soil

A limited number of soil samples were collected at several locations near the site boundary. These locations are shown in figure 8. The samples were collected and analyzed by the same techniques as those collected within the Livermore Valley. The concentrations of the various radionuclides of interest are given in table 19 and the resulting deposition levels are shown in table 20. Inspection of the data reveals that the activities of the artificially produced radionuclides may readily be accounted for as due to global fallout with no detectable contamination as a result of laboratory operations. The data in table 21, however, indicates that the uranium-235 to uranium-238 ratios are slightly depleted in uranium-235 with respect to those observed within the Livermore Valley. This may possibly be due to the depleted uranium being expended in the high explosive detonations at the site, although more data will be required to definitely ascertain this relationship.

Water

Monthly samples were collected from onsite wells supplying Site 300 and from various onsite and offsite springs, ponds, and creeks. The locations of these sites are shown in figure 7. Locations 1 through 7 represent deep-well sources, locations 11 and 14 are offsite creek sources, and rain water is collected at location 20. The remaining locations are onsite ponds or springs. The samples were subjected to gross alpha and beta analyses. No samples showed a gross alpha activity above the limit of detection of 1.2 pCi/liter. The gross beta activities averaged over 3-month periods are given in table 22. These activities show little variation with time and location and are similar to those exhibited by the water samples collected within the Livermore Valley.

These samples were also subjected to tritium analyses by electrolytic enrichment and subsequent scintillation counting. The results of the analyses are shown in table 23. With the ex-

Table 19. Activity levels of various radionuclides in soil at Site 300, 1971

Sampling location	Depth (cm)	Concentration (fCi/g)					Potassium-40 concentration (pCi/g)
		^{239}Pu	^{90}Sr	^{137}Cs	^{95}Zr	^{144}Ce	
1	0–1			370 ± 8%			
	0–24	3.3 ± 5%		61 ± 32%			4.6 ± 11%
2	0–1			530 ± 6%			2.7 ± 19%
	0–24	2.6 ± 10%		94 ± 19%	120 ± 26%	280 ± 38%	4.7 ± 11%
3	0–1			360 ± 7%			1.5 ± 8%
	0–24	1.3 ± 10%	47 ± 4%	50 ± 31%	62 ± 36%	230 ± 40%	5.6 ± 9%
4	0–24	2.3 ± 10%	51 ± 6%	100 ± 17%			4.8 ± 11%
5	0–1			560 ± 7%			
	0–24	5.3 ± 5%	62 ± 5%				
6	0–24	2.5 ± 5%	66 ± 6%				
7	0–25	2.7 ± 6%					
8	0–25	1.7 ± 6%					
9	0–25	1.7 ± 5%					
10	0–25	6.6 ± 4%					
11	0–25	2.0 ± 5%					
12	0–25	3.1 ± 6%					

Table 20. Deposition levels of various radionuclides in Site 300 soils, 1971

Sampling location	Concentration (mCi/km²)				
	^{239}Pu	^{90}Sr	^{137}Cs	^{95}Zr	^{144}Ce
1	0.89		14		
2	.78		25	1.5	3.5
3	.48	13	12	0.78	2.9
4	.72	15	25		
5	1.7	19			
6	.81	22			
7	.93				
8	.68				
9	.56				
10	2.3				
11	.74				
12	1.2				

Table 21. Concentrations of uranium in Site 300 soils, 1971

Sampling location	Depth (cm)	^{234}U (pg/g)	^{235}U (ng/g)	^{238}U (μg/g)	^{235}U/^{238}U [a]
1	0–24	116 ± 2%	18.0 ± 1%	2.60 ± 1%	0.0069
2	0–24	115 ± 10%	14.6 ± 1%	2.10 ± 1%	.0069
3	0–24	119 ± 10%	14.0 ± 1%	1.99 ± 2%	.0070
4	0–24	71.0 ± 10%	9.04 ± 1%	1.29 ± 2%	.0070
5	0–24	77.3 ± 10%	9.50 ± 1%	1.37 ± 2%	.0069
6	0–24	126 ± 10%	15.5 ± 1%	2.24 ± 2%	.0069
7	0–25	151 ± 10%	17.3 ± 1%	2.45 ± 1%	.0071
8	0–25	116 ± 12%	15.6 ± 1%	2.33 ± 1%	.0067
9	0–25	88.5 ± 11%	11.0 ± 1%	1.60 ± 2%	.0069
10	0–25	101 ± 12%	14.2 ± 1%	2.13 ± 1%	.0067
11	0–25	138 ± 10%	15.9 ± 1%	2.27 ± 1%	.0070
12	0–25	109 ± 11%	13.6 ± 1%	2.00 ± 1%	.0068

[a] The ^{235}U to ^{238}U ratio in natural uranium is 0.0072.

ception of samples collected at location 25, these samples contain tritium activities that are comparable with those observed in water samples collected within the Livermore Valley.

The elevated tritium activities observed at location 25 appear to be due to tritium being leached out of contaminated wastes that have been stored at a nearby location. Adjacent to this

Table 22. Average gross beta activities in Site 300 water samples, January–December 1971

Sampling location	Concentration (pCi/liter)			
	January-March	April-June	July-September	October-December
1	5.5	3.0	5.2	2.8
2	11.0	4.2	4.9	6.2
3	8.7	5.5	6.5	7.7
4	5.9	4.8	4.6	4.0
5	4.8	5.9	5.1	5.2
6	6.2	5.1	4.8	4.5
7	4.0	4.2	5.4	5.4
11	8.2	9.7	6.3	6.3
14	4.8	4.1	2.8	4.1
20	—	—	—	15
21	—	—	9.8	9.0
22	—	—	22	—
23	—	—	7.6	7.8
24	—	—	5.3	7.9
25	—	—	2.9	2.8
26	—	—	—	5.5
Average	6.6	5.2	6.7	6.3
Percent of AEC standard *	22	17	22	21

* AEC standard (beta activity) = 30 pCi/liter.

Table 23. Tritium activities in Site 300 water samples, 1971

Location	Concentration (pCi/liter)		Percent of AEC standard	Calculated annual adult whole body radiation dose (μrem)
	Maximum	Average		
1	18 ± 50%	16	0.000016	0.64
3	41 ± 22%	26	.000026	1.0
4	18 ± 50%	16	.000016	.64
6	36 ± 25%	31	.000031	1.2
7	150 ± 12%	35	.000035	1.4
8	36 ± 25%	20	.000020	.80
11	81 ± 11%	60	*.0020	2.4
14	36 ± 25%	28	*.00093	1.1
22	83 ± 13%	60	.000060	2.4
23	33 ± 26%	29	.000029	1.2
24	67 ± 13%	58	.000058	2.3
25	720,000 ± 2%	580,000	.[illegible]	2,300
26	750 ± 4%	740	*.025	30
Average		45,000		1,800

* Offsite AEC standard RCG (HTO) = 3,000,000 pCi/liter.
Onsite AEC standard RCG (HTO) = 100,000,000 pCi/liter.

spring is a deep-water well at location 6 which apparently has not been contaminated.

Table 23 also includes the calculated whole body doses to an adult consuming the water containing the listed tritium concentrations. These doses were derived in a manner similar to that used to compute the values listed in table 10. As one would expect, the doses are insignificant with the exception of location 25 where it would be possible for 23 mrem to be delivered to an individual consuming 1 liter per day from this spring. It is quite unlikely, however, for any individual to drink this water directly, since the water percolates back into the ground a few feet from the spring.

Vegetation

During the last quarter of 1971, vegetation samples were collected on a monthly basis at 7 sampling locations shown in figure 7. Dried monthly composite samples were subjected to gamma spectral analyses yielding the activities of cesium-137, cerium-144, zirconium-95, beryllium-7, and potassium-40. The average activities are shown in table 24. Also shown in the table are the calculated whole body or critical organ doses delivered to an adult by direct ingestion of 400 grams per day of edible vegetation containing 80 percent water and the listed activities. Again the data reveals that

Table 24. Radionuclide activities in Site 300 vegetation samples, 1971

Radionuclide	Average activity (pCi/g)	Calculated annual radiation dose to man via direct ingestion (mrem)	Critical organ
Cesium-137	0.14	0.26	Whole body
Cerium-144	.70	5.6	Lower large intestine
Zirconium-95	.078	.18	Lower large intestine
Beryllium-7	2.1	.11	Lower large intestine
Potassium-40	4.7	6.4	Whole body

potassium-40 and cerium-144 are the major contributors via this pathway.

These samples were also subjected to tritium analyses by freeze drying and subsequent electrolytic enrichment and scintillation counting of the resulting water. The average activities measured at each location are shown in table 25. With the exception of location 6, the activities show remarkably little fluctuation as compared with the results obtained from similar samples collected within the Livermore Valley.

Table 25. Tritium activities in Site 300 vegetation samples, 1971

Sampling location	Average tritium activity (pCi/liter)	Calculated annual adult radiation dose (μrem)
4	600	9.7
5	700	11
6	2,800	45
7	830	13
8	740	12
10	670	11
12	680	11
Average	1,000	16

Location 6 represents a waste disposal area where tritium-contaminated waste is stored. The table also includes the resulting whole body doses delivered to an adult by the tritium activities based upon the models referenced previously. As one would expect these doses are insignificant.

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2. Shippingport Atomic Power Station[3] January–December 1971

Duquesne Light Company
Shippingport, Pa.

The Shippingport Atomic Power Station is located on the south bank of the Ohio River on a 420-acre site. The site is approximately 1 mile from Midland, Pa., 5 miles from East Liverpool, Ohio, about 25 miles west of Pittsburgh, and about 11 miles below the confluence of the Beaver and Ohio Rivers (figure 9). The station is designed to produce electric energy by a conventional central station type turbine-generator unit. The pressurized water reactor consists of a closed system in which water is circulated by pumps over an array of nuclear fuel elements, or core, contained in a reactor vessel to heat exchangers where steam is formed in a separate isolated system.

Radioactive waste handled under the environmental program includes liquid and gaseous effluents released into the Ohio River and atmosphere, respectively. The levels of radioactivity released have been controlled to levels below the ones specified in the AEC standards (10 CFR 20). The releases have also been less than the limits imposed by the Ohio River Valley Water Sanitation Commission (ORSANCO) (*1*) and by the Commonwealth of Pennsylvania (*2*).

Liquid radioactive waste

The liquid radioactive wastes disposed of at Shippingport result mainly from draining the reactor coolant system and cleaning radioactive tools and equipment. The station is equipped with extensive systems to collect and process the waste water and remove most of the radioactivity before the purified water is discharged to the Ohio River.

The principal source of radioactivity in waste water is from trace amounts of corrosion and wear products from the metal surfaces of the reactor plant. These trace quantities are carried through the reactor by the coolant water and subsequently activated. The primary long-lived corrosion and wear product radionuclide is cobalt-60 (half-life of 5.3 years). A number of short-lived radionuclides are produced in the

---

[3] Summarized from Environmental Monitoring at Major U.S. Atomic Energy Commission Contractor Sites, Shippingport Atomic Power Station, January–December 1971.

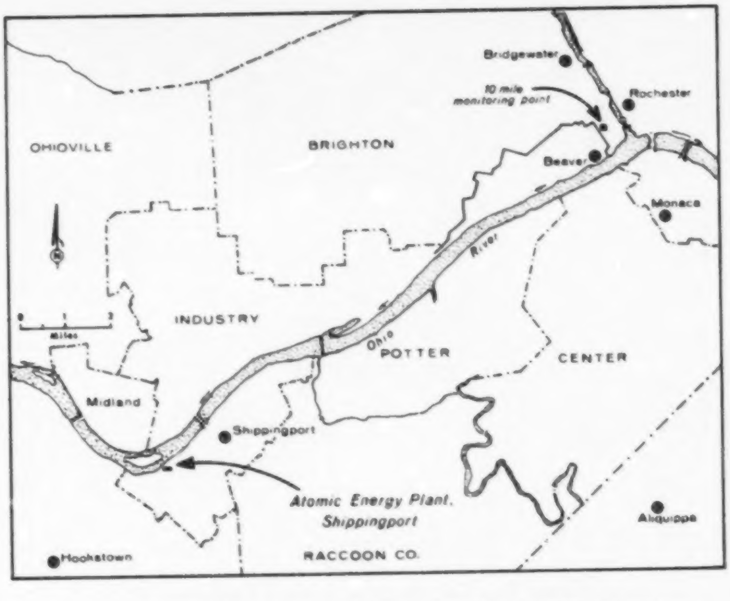

Figure 9. Shippingport Atomic Power Station sampling locations

reactor coolant as well as relatively long-lived tritium (12.3 years). Because of the small initial concentrations and rapid decay, the short-lived radionuclides disappear during holdup of liquid waste in the radioactive waste processing system, leaving the longer-lived tritium and cobalt-60.

During 1971, a total of 46 mCi gross beta-gamma radioactivity in the liquid waste (exclusive of tritium) and 0.66 Ci of tritium were released to the environment. The average releases to the environment for 1971 were 0.79 percent of the AEC standard for total activity (excluding tritium) and 0.016 percent for tritium.

Gaseous radioactive waste

Normal reactor operations produce radionuclides such as noble gases which occur from fission of trace uranium impurities in reactor structures and from irradiation of the water itself. The gases are removed from the primary coolant system periodically and contained for long periods of time to allow radioactive decay and sampling of the gases before their eventual release to the environment.

There were no releases of radioactive gases from the Shippingport radioactive waste system for 1971. In retrospect, the radioactive noble gas releases (primarily xenon-133) for the years 1969 and 1970 were 75 μCi and 19 μCi, respectively. Total airborne and gaseous radioactivity released from Shippingport over its entire operational history since December 1957 has been less than one curie. The annual liquid and gaseous radioactive waste discharges for 1969–1971 are shown in table 26. The discharge points for liquid and gaseous effluent are shown in figure 10.

Table 26. Annual liquid and gaseous radioactive waste discharges, Shippingport Atomic Power Station 1969–1971

Year	Radioactive liquid wastes released to the Ohio River		Gaseous wastes released to the environment (μCi)
	Total activity (excluding tritium) (mCi)	Tritium activity (Ci)	
1969	210	20.1	75
1970	71	1.71	19
1971	46	.66	[a] 0

[a] No gases were released due to adequate holdup capacity.

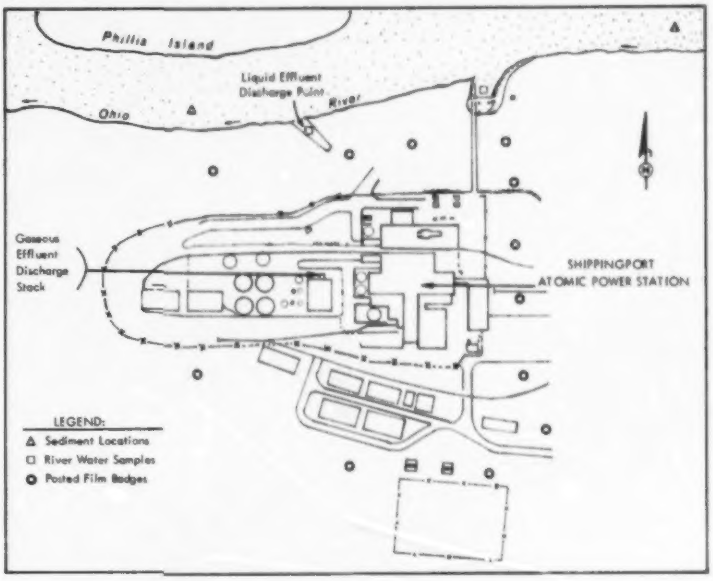
Phillis Island
Ohio
River
Liquid Effluent Discharge Point
Gaseous Effluent Discharge Stack
SHIPPINGPORT ATOMIC POWER STATION
N
LEGEND:
△ Sediment Locations
□ River Water Samples
○ Posted Film Badges

Figure 10. Shippingport liquid and gaseous effluent discharge points

Table 27. Gross radioactivity in the Ohio River, Shippingport Atomic Power Station, January–December 1971

Type of radioactive material	Number of samples	Average concentration (pCi/liter)									
		Upstream				Range Jan–Dec	Downstream				Range Jan–Dec
		Jan–Mar	Apr–June	July–Sept	Oct–Dec		Jan–Mar	Apr–June	July–Sept	Oct–Dec	
Alpha:[a]											
Total solids	13	1.4	1.7	1.0	1.5	0.2– 5.9	1.3	0.8	1.4	1.6	0.3– 5.2
Beta:[b]											
Total solids	13	9.0	13.3	13.7	9.7	2.7–35.1	8.9	12.5	12.8	10.2	2.9–38.0
Potassium-40 [c]	13	4.4	5.0	7.2	6.7	2.9– 8.6	4.5	5.0	7.2	6.7	3.2– 8.6

[a] The 90-percent confidence level of average alpha radioactivity determinations is 0.2 pCi/liter.
[b] The 90-percent confidence level for average beta-gamma radioactivity determination is 0.7 pCi/liter.
[c] The 90-percent confidence level for average potassium-40 radioactivity determination is 0.4 pCi/liter.

Environmental monitoring

Environmental monitoring surveys adjacent to the Shippingport plant have been performed since before initial startup in 1957 and a continuous environmental monitoring program has been carried out during its 14 years of operation to assure the adequacy of waste discharge procedures and limits and to monitor radiation exposure outside the station. This exposure to the general public has not been greater than that received from natural background radiation. These surveys have been reviewed by both the AEC and independently by the Bettis Atomic Power Laboratory. Water from both upstream and downstream sampling points in the Ohio River has been sampled continuously and analyzed weekly, sediment samples from the river have been taken quarterly from upstream and downstream sampling points, and film badges around the boundary of the station and from a 10-mile distant control point have been evaluated monthly.

Ohio River water analysis

During 1971, weekly composite samples were analyzed from two continuous automatic samplers in the station circulating water line upstream and downstream of the radioactive waste effluent release point. These samples were analyzed for gross alpha and beta-gamma radioactivity on both suspended and dissolved solids and also for potassium-40 content. As shown in table 27, no significant difference was observed among the average alpha, beta-gamma and potassium-40 radioactivities for the influent and effluent samples taken from the river during 1971.

Ohio River sediment analysis

The Ohio River bottom silt in the vicinity of Shippingport is sampled quarterly upstream and downstream of the plant outflow. During the years of plant operation, and even before plant operations began in 1957, measurements of sediment have shown a wide variation in radioactivity—both upstream and downstream—caused by uranium, thorium and daughter products of radium which occur naturally throughout the Ohio River Basin and are washed into the river. Over the years 1967 through 1971 the radioactivity in silt samples taken upstream from Shippingport (thus reflecting natural radioactivity) varied between 2.5 and 17.0 pCi/g, with an average value of 8.2 pCi/g. This wide variation was also exhibited in the downstream silt measurements, which have an average value of 9.0 pCi/g. Consistent with the results of previous years, there is no significant difference between the 1971 upstream and downstream sediment sample activities. Shippingport Atomic Power Station discharges have had no significant effect on the radioactivity levels of the river sediment.

Environmental gamma radiation

Twelve film badges for detecting beta-gamma radioactivity were posted monthly throughout the year at the site perimeter in an attempt to determine the external radiation exposure in the immediate area. To determine the normal background levels of radiation in the vicinity of the station, a control film badge location was established at a point 10 miles from the station boundary in Bridgewater, Pa.

For 1971, the densities of the site perimeter monitoring films were not measurably different from the control film density. This indicates that the radiation exposure to the general public outside the station was not above that received from natural background radiation.

Conclusions

The radioactive discharges processed from the Shippingport Atomic Power Station have not accumulated or concentrated radioactive wastes in the environs surrounding the station. All discharges of radioactive waste materials have been carried out in strict compliance with existing Federal, regional, and State of Pennsylvania regulations. The overall trend in quantities of radioactive waste effluents released to the environs in recent years has steadily decreased.

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Recent coverage in *Radiation Data and Reports:*

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January–December 1970	November 1972

79

Reported Nuclear Detonations, September 1973

(Includes seismic signals presumably from foreign nuclear detonations)

Seismic signals from a Soviet underground nuclear explosion in the yield range of 3 to 6 megatons were recorded by the United States on September 12, 1973. The signals originated at approximately 3:00 a.m. (EDT) at the Novaya Zemlya nuclear test area in the Arctic. This test had about the same yield as the one of October 14, 1970, which was the largest Soviet underground test detected by the United States.

Seismic signals, presumably from a Soviet underground nuclear explosion, were recorded by the United States. The signals originated at approximately 11 p.m. (EDT) September 18, 1973, in the central Kazakh Desert and were equivalent to those of an underground nuclear explosion in the yield range of 20 to 200 kilotons.

On September 27, 1973, seismic signals, presumably from a Soviet underground nuclear explosion, were recorded by the United States at approximately 3 a.m. (EDT). The signals originated in Southern Novaya Zemlya in the Arctic and were equivalent to those of an underground nuclear explosion in the yield range of 20 to 200 kilotons.

The U.S. Atomic Energy Commission announced that the United States had recorded seismic signals, presumably from a Soviet underground nuclear explosion on September 30, 1973. The signals originated from the southern Ural area and were equivalent to those of an underground nuclear explosion in the yield range of 20 to 200 kilotons.

There were no reported nuclear detonations for the United States for September 1973.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U.S. nuclear detonations may be obtained upon request from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

A HISTORY AND PRELIMINARY INVENTORY REPORT ON THE KENTUCKY RADIOACTIVE WASTE DISPOSAL SITE.

David T. Clark. Radiation Data and Reports, Vol. 14, October 1973, pp. 573–585.

The Kentucky radioactive waste disposal site, operated by the Nuclear Engineering Company, Incorporated, has been in operation since March 1963. As of January 1, 1972, approximately 0.71 million cubic meters of waste, containing 1,153,333 curies of byproduct material, 208,903 grams of special nuclear material, and 39,493 kilograms of source material, have been disposed of at this facility. Due to the relatively long period of operation and the large quantities of radioactive material involved, a detailed inventory of two of the largest pits at the site was made, based on available disposal records. This report contains a brief history of this facility and a summary of the inventory results.

KEYWORDS: Disposal, Kentucky, liquids, radioactive waste, solids, storage.

RADIATION DATA AND REPORTS

Volume 14, Number 11, November 1973

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

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U.S. ENVIRONMENTAL PROTECTION AGENCY
Russell E. Train, Administrator

Reports

Evaluation of Uranium Mine Atmospheres by Measurements of the Working Level and Radon

Duncan A. Holaday and James H. Jones[1]

Using estimates of equilibrium ratios and concentrations of unattached atoms in uranium mines, calculations were performed and results presented of the amount of alpha energy per liter of air per working level available to be imparted to the various regions of the respiratory tract. It was discovered that the factor that caused the greatest effect on the alpha energy that could be deposited in the lungs was a change in the unattached fraction of the radon daughters. If the radon concentration was used to determine potential exposure, radon to daughter ratios also had a marked effect on the potential alpha energy deposition.

The primary radiation health hazards in uranium mines are created by radon-222 and its short-lived daughters, polonium-218 (RaA), lead-214 (RaB), bismuth-214 (RaC) and polonium-214 (RaC′). In almost all mining situations, the hazard from radon is believed to be negligible compared to that produced by the airborne daughters, so methods of evaluating mine atmospheres have been directed towards estimating concentrations of the daughters. Ideally, measurements should be made of radon, each individual daughter, the concentration and size distribution of particulates, and the fractions of each daughter which exist as "free atoms." In practice, two procedures have been used in control programs, (1) measurements of radon and (2) measurement of the potential alpha energy of the daughters, based on the assumptions that approximately the same fraction of each would be deposited in the respiratory tract with similar distributions in the various parts of the lung and that most of the daughters which were deposited in the lung decayed to lead-210 (RaD) before clearance. It was recognized that both of these assumptions are only approximately true.

A number of studies have been reported in which the radiation dose to the lung from alpha particles was calculated using a variety of hypothetical mine atmospheres and several lung models which show that there is no constant ratio between working levels and rads. The variations in the calculated ratios are large when extreme conditions are considered, such as equilibrium ratios of RaA:RaB:RaC = 1:1:1 and RaA:RaB:RaC = 1:0:0 with fractions of unattached atoms varying from 1 to 0. These studies raise serious questions of the suitability of use of measurements of the working level for control purposes. Measurements of radon followed by estimation of daughter concentrations and fractions of free atoms could be used if conditions were relatively stable. Conditions in mines, however, may vary widely from hour to hour. The same variations will also alter the validity of working level (WL) measurements.

Effect of radon daughter equilibrium ratios and fractions of free atoms in lung dose calculations

Two in-depth reviews of the subject of lung dosimetry are available: those of Nelson, et al. (*1*) and Walsh (*2*). Nelson concluded that the fractions of free atoms were a more important parameter in affecting dose than were the relative proportions of daughters, for the hypothetical atmosphere which they considered. Walsh also concluded that the relative concentrations of RaA, RaB, and RaC were not important because most of the radiation dose is due to RaC′ alphas. Walsh considered that for continuous exposure the mean elimination rate for radon daughters is much longer than the physical half-life and although radon daughters may not decay at the site of deposition, they will in the long run be replaced by atoms which will decay there, so there is effectively little clearance from the lung. The fractions of uncombined RaA, RaB, and RaC, however, were important in determining lung radiation dose.

---

[1] Mr. Holaday was and Mr. Jones is with the Division of Field Studies and Clinical Investigations, NIOSH, Salt Lake City, Utah. Mr. Holaday is retired.

Existing conditions in American mines

An extensive and intensive study of the radiological characteristics of uranium mine atmospheres was reported by Breslin, George, and Weinstein (*3*). As part of this work, mean daily radon daughter equilibrium ratios were determined in 36 locations in 6 mines in New Mexico and Colorado. Data on radon and radon daughter concentrations were obtained in only six mines, which were considered to be representative of uranium mines in the industry. The fractions of free atoms were not measured in this study.

Raghavayya and Jones (*4*) recently surveyed five mines in New Mexico and six in Colorado specifically to measure daughter equilibrium ratios and fractions of free atoms. A modified Tsivoglou method was used to calculate equilibrium ratios and a wire screen procedure was used to estimate the fractions of each individual daughter.

Equilibrium ratios

In both of the studies referred to, the radon daughter equilibrium ratios were found to vary over wide ranges. The highest ratios were almost 1:1:1 while the lowest were 1:0.2[illegible]:0.03. The median ratios in the mines surveyed by Raghavayya and Jones were 1:0.56:0.42. The ratio between radon and RaA also varied widely particularly in the surveys by Raghavayya and Jones. As stated above, the AEC data were composed of mean daily averages at each station, while the NIOSH data are composed of individual samples at each station which may account for some of the wider distribution of ratios found in the latter work. Daughter equilibrium ratios are affected by such factors as rate of air change in the area, rate of radon emission into the area from broken rock or host rock, contamination of ventilation air from many sources, and plating out of radon daughters on surfaces. Thus, it is impossible to predict equilibrium ratios from ventilation measurements only.

Unattached atoms

The question of the fraction of each daughter present in the atmosphere as "unattached" atoms is important. It has been considered that in usual mine situations only small fractions of the RaB and RaC atoms will be present in this form, consequently, these fractions have been ignored in lung dose calculations. Measurements of unattached atoms are not easy, primarily because (as was pointed out by Breslin) there is no sharp distinction between unattached and attached atoms, but rather a spectrum of particle sizes. Therefore, the fractions of unattached atoms found are, in some degree, dependent on the method of measurement. The data reported by Raghavayya and Jones are not necessarily precise, but they do serve to give relative evaluations of fractions of unattached atoms of each daughter which may exist in actual mine situations.

The significant findings of these workers was that, contrary to prior theory, appreciable fractions of RaB and RaC do occur in mine atmospheres. The fractions of free daughter atoms ranged from RaA, 32.7 percent; RaB, 25.6 percent; RaC, 16.9 percent to RaA, 1.8 percent; RaB, 4.8 percent; RaC, 3.5 percent with a median value of RaA, 4.6 percent; RaB, 6.5 percent; RaC, 4.4 percent. Factors which affect the attachment of radon daughter atoms to particles include numbers of radioactive atoms per cm^3, number of particles per cm^3, number of negative ions per cm^3 available for neutralizing daughter ions, and recoil detachment of daughter atoms from particles. A laboratory study by McLaughlin (*5*) also found that unexpectedly large fractions of RaB and RaC existed as unattached atoms.

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Discussion

In studies of the effect of variations in equilibrium ratios and fractions of free atoms on lung radiation doses, hypothetical conditions have been used because of the paucity of information on actual situations. The findings of the NIOSH surveys can be employed to give further insight into this question. For these calculations, the following assumptions were made.

1. In all cases, the radon daughter concentration was 1 WL.
2. All the daughter activity existed as unattached atoms or was attached to particles 0.2 μm in diameter.
3. Nose breathing removed 50 percent of the unattached atoms and 10 percent of those on particles. Mouth breathing removed approximately 10 percent of the unattached atoms and none of the particles.
4. The regional depositions were calculated in accordance with the procedure described by Altshuler et al. (*6*).

The numbers of daughter atoms of each species deposited in several regions of the respiratory tract were calculated using several combinations of equilibrium ratios and fractions of unattached atoms. The available alpha energy from radioactive decay deposited in each region was also calculated and the total value is given below each table.

Table 1. Regional deposition of radon daughter atoms per liter of air inhaled

Conditions: **Atmospheric concentration of radon daughters = 1 WL**
Equilibrium ratio; RaA:RaB:RaC = 1:0.56:0.42 (median of ratios found)
Percent unattached atoms; RaA = 32.7, RaB = 25.6, RaC = 16.9
Nose breathing

Region of respiratory tract	Atoms of RaA deposited		Atoms of RaB deposited		Atoms of RaC deposited	
	Unattached	Attached	Unattached	Attached	Unattached	Attached
Trachea	15	0	60	0	22	0
Main bronchi	30	0	118	0	43	0
Lobar	56	0	216	0	79	0
Segmental	72	11	279	60	102	37
Subsegmental	72	44	279	240	102	147

Total available alpha energy deposited = 17,638 MeV.

Table 1 shows the results using the median equilibrium ratio and the highest values for unattached atoms, while table 2 displays the calculations using the median ratio and the lowest values for free atoms. The high fractions of free atoms result in deposition of about 2.5 times the amount of potential alpha energy per liter per working level as do the low values.

Table 2. Regional deposition of radon daughter atoms per liter of air inhaled

Conditions: **Atmospheric concentration of radon daughters = 1 WL**
Equilibrium ratio; RaA:RaB:RaC = 1:0.56:0.42 (median of ratios found)
Percent unattached atoms: RaA = 1.8, RaB = 4.8, RaC = 3.5
Nose breathing

Region of respiratory tract	Atoms of RaA deposited		Atoms of RaB deposited		Atoms of RaC deposited	
	Unattached	Attached	Unattached	Attached	Unattached	Attached
Trachea	1	0	11	0	0	0
Main bronchi	2	0	22	0	9	0
Lobar	3	0	41	0	16	0
Segmental	4	16	52	77	21	43
Subsegmental	4	64	52	307	21	171

Total available alpha energy deposited = 7,715 MeV.

Tables 3 and 4 display similar data using the median values for fractions of unattached atoms with the highest and lowest equilibrium ratios found, respectively. These calculations

Table 3. Regional deposition of radon daughter atoms per liter of air inhaled

Conditions: **Atmospheric concentration of radon daughters = 1 WL**
Equilibrium ratio; RaA:RaB:RaC = 1:0.21:0.03 (lowest ratios found)
Percent unattached atoms; RaA = 4.6, RaB = 6.5, RaC = 4.4 (median values)
Nose breathing

Region of respiratory tract	Atoms of RaA deposited		Atoms of RaB deposited		Atoms of RaC deposited	
	Unattached	Attached	Unattached	Attached	Unattached	Attached
Trachea	5	0	14	0	1	0
Main bronchi	11	0	28	0	2	0
Lobar	19	0	51	0	3	0
Segmental	25	38	65	69	5	7
Subsegmental	25	154	65	309	5	29

Total available alpha energy deposited = 8,730 MeV.

show that wide variations in equilibrium ratios influence the potential alpha energy deposited per liter per working level only slightly.

Table 4. Regional deposition of radon daughter atoms per liter of air inhaled

Conditions: Atmospheric concentration of radon daughters = 1 WL
Equilibrium ratio; RaA:RaB:RaC = 1:1.0:0.98 (highest ratios found)
Percent unattached atoms: RaA = 4.6, RaB = 6.5, RaC = 4.4 (median values)
Nose breathing

Region of respiratory tract	Atoms of RaA deposited		Atoms of RaB deposited		Atoms of RaC deposited	
	Unattached	Attached	Unattached	Attached	Unattached	Attached
Trachea	1	0	15	0	7	0
Main bronchi	2	0	30	0	15	0
Lobar	4	0	55	0	27	0
Segmental	6	9	70	75	34	55
Subsegmental	6	35	70	299	34	221

Total available alpha energy deposited = 8,510 MeV.

Table 5. Regional deposition of radon daughter atoms per liter of air inhaled

Conditions: Atmospheric concentration of radon daughters = 1 WL
Equilibrium ratio; RaA:RaB:RaC = 1:0.47:0.25 (actual ratios found)
Percent unattached atoms; RaA = 32.7, RaB = 25.6, RaC = 16.9
Nose breathing

Region of respiratory tract	Atoms of RaA deposited		Atoms of RaB deposited		Atoms of RaC deposited	
	Unattached	Attached	Unattached	Attached	Unattached	Attached
Trachea	19	0	62	0	16	0
Main bronchi	38	0	124	0	32	0
Lobar	70	0	227	0	58	0
Segmental	91	14	293	70	76	30
Subsegmental	91	55	293	279	76	122

Total available alpha energy deposited = 18,500 MeV.

Table 5 uses the highest fractions of unattached atoms found with the equilibrium ratio that existed at that station, while table 6 uses the lowest fractions of unattached atoms with the corresponding ratios. The particle counts at each station also are given The total energy deposited in each case is very similar to those found in tables 1 and 2, respectively.

Table 6. Regional deposition of radon daughter atoms per liter of air inhaled

Conditions: Atmospheric concentration of radon daughters = 1 WL
Equilibrium ratio; RaA:RaB:RaC = 1:0.61:0.56 (actual ratios found)
Percent unattached atoms; RaA = 1.8, RaB = 4.8, RaC = 3.5
Nose breathing

Region of respiratory tract	Atoms of RaA deposited		Atoms of RaB deposited		Atoms of RaC deposited	
	Unattached	Attached	Unattached	Attached	Unattached	Attached
Trachea	1	0	11	0	5	0
Main bronchi	1	0	21	0	10	0
Lobar	3	0	39	0	19	0
Segmental	4	14	50	73	25	50
Subsegmental	4	56	50	292	25	200

Total available alpha energy deposited = 7,741 MeV.

These calculations show that the primary factors influencing the amount of potential alpha energy deposited in the respiratory tract per WL are the fractions of unattached atoms. This deposited activity is subject to removal from the lung by clearance mechanisms such as mucus flow or direct passage from the lung to the blood.

The data obtained in the NIOSH mine surveys can also be used to estimate the influence of varying radon to daughter ratios on MeV of available alpha energy deposited. This question is important when atmospheric concentrations of radon are employed as the measure of relative biological hazard. Tables 7 and 8 illustrate this effect in two actual situations, one with a relatively high equilibrium ratio and the other with a relatively low ratio. The fractions of free atoms were those actually found, and the data were normalized to a radon concentration of 100 pCi/liter. These tables show that varying equilibrium ratios have a marked effect on the MeV of available alpha energy deposited per liter per pCi of radon. In these cases, the available alpha energy deposited varies by a factor of almost 6.

The calculations described above have shown that there is an appreciable effect on the potential alpha energy deposited in the lungs, caused by a change in the unattached fraction of radon

Table 7. Regional deposition of radon daughter atoms per liter of air inhaled

Conditions: **Atmospheric concentration of radon daughters = 100 pCi/liter**
Equilibrium ratio; Rn:RaA:RaB:RaC = 1:0.84:0.83:0.81
Percent unattached atoms; RaA = 4.0, RaB = 5.6, RaC = 3.5
Radon concentration = 100 pCi/liter
Nose breathing

Region of respiratory tract	Atoms of RaA deposited		Atoms of RaB deposited		Atoms of RaC deposited	
	Unattached	Attached	Unattached	Attached	Unattached	Attached
Trachea	1	0	10	0	5	0
Main bronchi	2	0	21	0	9	0
Lobar	3	0	38	6	17	0
Segmental	4	7	49	61	22	45
Subsegmental	4	28	49	270	22	178

Total available alpha energy deposited = 6,716 MeV.

Table 8. Regional deposition of radon daughter atoms per liter of air inhaled

Conditions: **Atmospheric concentration of radon daughters = 100 pCi/liter**
Equilibrium ratio; Rn:RaA:RaB:RaC = 1:0.36:0.13:0.08
Percent attached atoms; RaA = 3.9, RaB = 6.2, RaC = 6.1
Radon concentration = 100 pCi/liter
Nose breathing

Region of respiratory tract	Atoms of RaA deposited		Atoms of RaB deposited		Atoms of RaC deposited	
	Unattached	Attached	Unattached	Attached	Unattached	Attached
Trachea	0	0	2	0	1	0
Main bronchi	1	0	4	0	2	0
Lobar	1	0	7	0	3	0
Segmental	2	3	9	9	4	4
Subsegmental	2	12	9	38	4	10

Total available alpha energy deposited = 1,137 MeV.

daughters. If radon concentration is used to determine potential exposure, radon to daughter ratios also have a marked effect on potential alpha energy deposition. The extremes determined in these calculations are based on conditions found in actual working mines. The data contained in the tables will allow lung doses to be calculated, using actual rather than theoretical conditions.

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Radiological Survey of New London Harbor, Thames River, Conn., and Environs

Sam T. Windham[1] *and Charles R. Phillips*[2]

In July 1972, the Eastern Environmental Radiation Facility, in cooperation with the U.S. Naval Ship Systems Command, conducted a radiological survey of the New London Harbor, Thames River and environs to determine if nuclear ship activity in that area has contributed radioactivity which could result in detectable radiation exposure to the public. Comparison with a similar survey conducted in 1966 show that cobalt-60 activity levels in sediment have decreased by an average factor of 33 due to a reduction in the amount of radioactivity discharged, radioactive decay and natural sedimentation. Analysis of samples indicative of direct pathways for human exposure lead to the conclusion that no significant radiation exposure to the public has resulted from nuclear ship operations in this area. It is concluded that the environmental surveillance routinely conducted by the Navy should be adequate to assure protection of the public from the routine nuclear ship operations.

The Eastern Environmental Radiation Facility[3] (EERF) of the U.S. Environmental Protection Agency in cooperation with the U.S. Naval Ship Systems Command (NAVSHIPS) has conducted radiological surveillance programs in a number of ports which serve nuclear-powered vessels. These studies were begun in 1963 and were conducted at ports on the East, West, and Gulf Coasts of the United States and in Pearl Harbor, Hawaii. These surveys were undertaken to determine if nuclear-powered vessel operations, including berthing, repair and servicing, had resulted in environmental radioactivity levels which could contribute a detectable radiation exposure to the public. The survey of the harbor at Groton-New London, Conn., in July 1972 was a followup of a previous survey at this port conducted in 1966 (*1*).

Consideration in design of the survey

A primary consideration in the protocol for the survey was to be able to make a comparison between the radioactivity levels present in the harbor environs in 1972 and those present in 1966. Sampling procedures and locations were selected so that direct comparisons could be made with the data obtained in the 1966 survey wherever practical. Locations of vessels and additions and changes in the docks prevented resurveying of some of the locations used in 1966.

Previously published data (*2*) show that the quantity of radioactivity discharged annually into the Groton-New London Harbor was reduced by a factor of 10 between 1967 and 1971. The total quantity of radioactivity discharged to the harbor by Electric Boat Division, the U.S. Submarine Base, and the submarine tender at State Pier in calendar year 1971 was less than 0.001 curie, excluding tritium.

Characteristics of the Thames River and environs

The Thames River is a tidal estuary arising at the confluence of the Yantic and Shetucket Rivers approximately 24 km (15 miles) north of the Groton-New London harbor area. The river varies in width from 0.21 km (0.13 miles) to a maximum of 1.82 km (1.13 miles) where it empties into Long Island Sound. The mean tidal range of the river at New London is 76 cm (2.5 feet).

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The bottom sediment is characterized mainly by mud, gravel, and sand. Because of silting, maintenance dredging is required in the channel and in the areas adjacent to the piers. Between the 1966 and 1972 surveys, dredging had been done in an area adjacent to pier 17 and the marine railway at the submarine base and in the area north of the State pier. The material removed in the dredging operation is transported by barge to a dumping area at sea.

Personal communications with local authorities indicated no commercial fishing is done in the Groton-New London Harbor area, although sport fishing and power and sail boating are popular. There appeared to be no swimming in the harbor area with the public swimming areas located on Long Island Sound.

Both Groton and New London obtain their city water supplies from reservoirs fed by surface streams. The harbor area is industrialized with essentially no agriculture along the shore. The major industries in the harbor area are the U.S. Submarine Base, General Dynamics Electric Boat Division, and Charles Pfizer and Sons.

Survey and analytical methods

An underwater scintillation probe containing a 10 by 10 cm NaI(Tl) detector was used in conjunction with a multichannel pulse height analyzer to obtain gamma spectra of the harbor bottom sediment.

Probe measurements were made by lowering the detector to the harbor bottom and counting for 10 minutes. A background spectrum was taken at the same location as in the 1966 survey and automatically was subtracted from subsequent spectra. This area (location 1) is located at "light 14" just above Dow Chemical Company and should be unaffected by nuclear ship operations downstream (figure 1). Data were printed out on a parallel printer.

The probe was used as a semiquantitative tool in conjunction with bottom sediment samples on which quantitative radionuclide analyses were performed in the laboratory. Data obtained using the probe were useful in delineating general areas of radioactivity whereas the laboratory analysis of sedment samples taken within these areas provided quantitative results.

A standard Petersen dredge was used to sample approximately the top 10 cm of sediment. The samples were prepared for analysis by drying at 110°C and grinding to a fine powder. The samples were gamma counted in a 1-liter Marinelli beaker on a 10 by 10 cm NaI (Tl) detector using a multichannel analyzer.

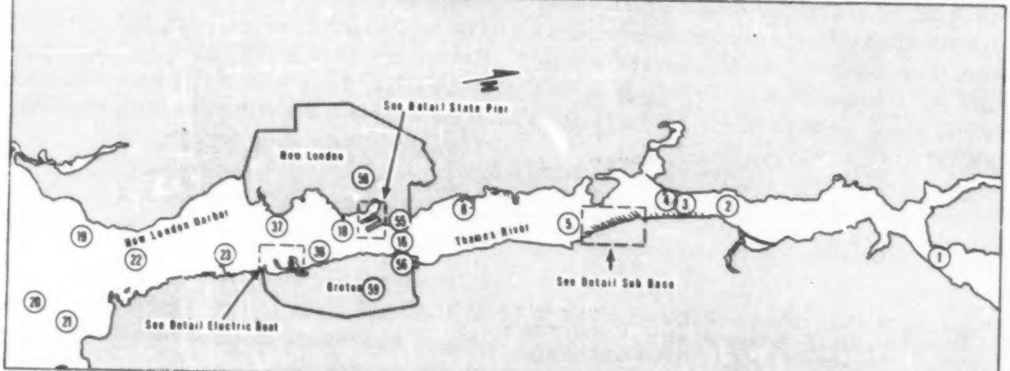

Figure 1. Thames river, New London harbor sampling locations

Vegetation samples (*Fucus*, an intertidal rockweed) were collected as available in the harbor area. The samples collected were generally found growing on rocks and pier pilings. The vegetation samples were dried at 110°C, ground to a fine powder, and counted in a "cottage cheese container" on a 10 by 10 cm NaI (Tl) detector.

Fish samples were caught in the harbor area and lobsters were purchased from a local distributor. The lobsters were trapped in the Long Island Sound area and represented the source of commercial lobsters caught nearest to the Groton-New London area. In the laboratory, these samples were chopped individually to an even consistency and counted wet in a 1-liter Marinelli beaker on a 10 by 10 cm NaI (Tl) detector.

Harbor water and drinking water from the Groton and New London municipal supplies were collected. Analysis consisted of a direct gamma spectrum analysis of 3.5 liters in a Marinelli beaker plus a gamma analysis (well crystal of a 40-ml concentrate from an evaporated 4-liter sample.

Core samples of the harbor bottom were collected by divers at several locations. These samples were used to define the vertical distribution of radioactivity in the harbor bottom. The samples were collected by pushing a 2.5 cm diameter by 61-cm long plastic tube into the sediment as far as possible and then capping the ends of the tube. In the laboratory, the cores were cut into 2.5 cm segments and counted in a 10 by 10 cm NaI (Tl) well crystal.

Results and discussion

Figures 1–8 show the sampling locations for the 1972 survey and the cobalt-60 concentration as indicated by the analysis of sediment samples from these locations (table 1). Previous surveys have shown cobalt-60 to be the predominant radioisotope introduced into the environment as a result of nuclear operation *(1)*. For comparison, the cobalt-60 activities found in the 1966 and 1972 surveys are given in table 2 for all common sampling locations. At these common sampling locations it is seen that the cobalt-60 levels are lower by an average factor of 33 in the 1972 survey as compared to the 1966 survey. This reduction is due largely to the effects of reducing the quantity of radioactivity discharged to the harbor, the effects of natural sedimentation in the estuary,[4] and loss by radioactive decay. Measurements made using the underwater gamma probe substantiated this reduction in activity based on the spectra obtained on the two surveys.

Conversations with local residents and seafood suppliers indicated that there is no commercial fishing in the harbor area; therefore, fish samples were difficult to obtain. Flounder and a species of nonedible fish which were analyzed showed no detectable amounts of cobalt-60. Other than natural activity and a trace of zirconium-niobium-95 attributed to fallout in

Table 1. Results of silt analysis, Groton, Conn. harbor survey, July 1972

Sample ID	Cobalt-60 [a] activity (pCi/g dry weight)	Sample ID	Cobalt-60 [a] activity (pCi/g dry weight)	Sample ID	Cobalt-60 [a] activity (pCi/g dry weight)
GS-1	1.1± 4%	GS-17	6.6± 2%	GS-33	9.5± 1%
GS-2	.4± 6%	GS-18	2.0± 3%	GS-34	10.3± 1%
GS-3	.9± 4%	GS-19	1.0± 4%	GS-52	1.4± 4%
GS-5	.8± 5%	GS-22	.4± 7%	GS-55	1.5±11%
GS-7	2.4± 2%	GS-24		GS-56	.2± 8%
GS-8	4.0± 2%	GS-25	1.1± 4%	GS-38	1.3± 4%
GS-12	5.5± 2%	GS-26	2.3± 3%	GS-41	1.4± 3%
GS-13	1.7± 3%	GS-28	1.4± 3%	GS-43	1.3± 3%
GS-14	3.2± 2%	GS-29	1.5± 3%	GS-45	1.5± 3%
GS-16-A	.9± 5%	GS-30	2.5± 3%	GS-46	1.5± 3%
GS-16-B	.9± 5%	GS-31	2.5± 3%	GS-48	1.9± 3%
GS-16-C	.8± 6%	GS-32	26.1± 1%	GS-51	1.0± 4%

[a] Analysis of samples for potassium-40, zinc-65, zirconium-niobium-95, ruthenium-106, cesium-137, cerium-144, bismuth-214, and thorium-232 indicated levels of activity which were consistent with natural background and fallout from weapons testing.

The error expressed is the percentage of the 2-sigma counting error for a normal distribution.

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[4] Natural sedimentation could cause a reduction in cobalt-60 concentrations by diluting contaminated sediment with uncontaminated sediment and by covering the contaminated sediment.

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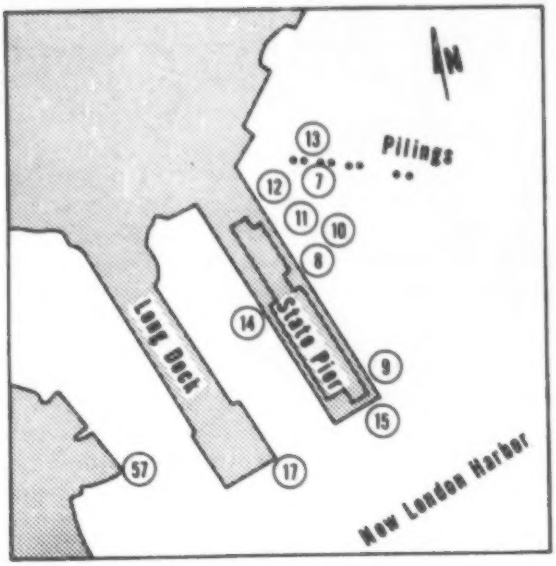
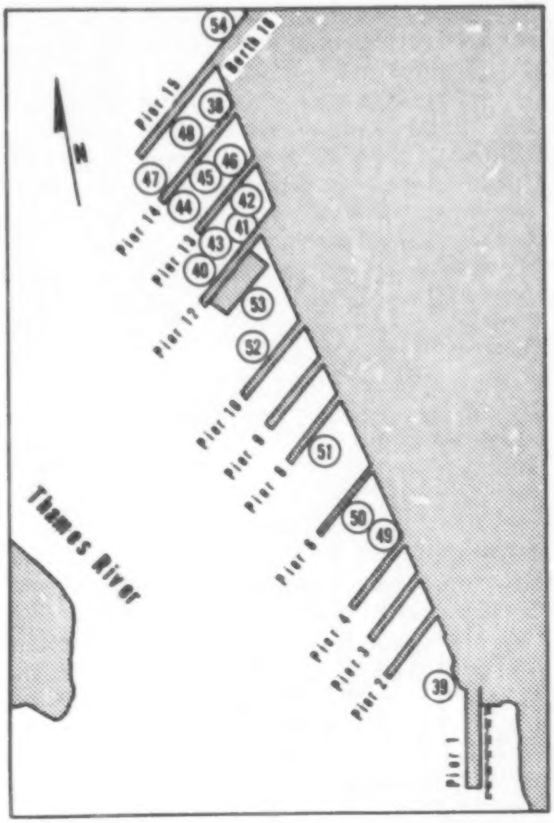

N
13
Pilings
12
7
11
10
8
14
State Pier
Long Dock
9
15
57
17
New London Harbor

Figure 2. State pier detail—sampling locations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Pier 15
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Pier 14
Pier 13
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Pier 12
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52
Pier 10
Pier 8
Pier 6
51
50
49
Pier 4
Pier 3
Pier 2
39
Pier 1
Thames River

Figure 3. Submarine base detail—sampling locations

one lobster sample, no radioactivity was found in any of these samples. Data from analysis of these samples are in table 3.

Fucus, an intertidal rockweed, was the only readily available vegetation in the harbor area. The locations and results of the gamma analysis of these samples are detailed in table 4. From the data it is seen that trace amounts of cobalt-60 were present in samples collected near the State Pier and Long Dock. Other than the cobalt-60, the samples contained only varying amounts of natural background and fallout activity.

Table 2. Comparison of cobalt-60 activity in sediment samples collected in 1966 and 1972

1972 location	Cobalt-60 activity (pCi/g dry weight) 1966	Cobalt-60 activity (pCi/g dry weight) 1972	Reduction factor[a]	1972 location	Cobalt-60 activity (pCi/g dry weight) 1966	Cobalt-60 activity (pCi/g dry weight) 1972	Reduction factor[a]	1972 location	Cobalt-60 activity (pCi/g dry weight) 1966	Cobalt-60 activity (pCi/g dry weight) 1972	Reduction factor[a]	1972 location	Cobalt-60 activity (pCi/g dry weight) 1966	Cobalt-60 activity (pCi/g dry weight) 1972	Reduction factor[a]
1	1.0	1.1		15	NS	NS		29	NS	1.5		43	21.0	1.3	16.2
2	NS	.4		16	32.0	0.9		30	362	2.5	144.8	44	30.4	NS	
3	NS	.9		17	NS	6.6		31	20.3	2.5	8.12	45	NS	1.5	
4	4.8	NS		18	NS	2.0		32	NS	26.1		46	14.4	1.5	9.6
5	NS	.8		19	NS	1.0		33	NS	9.3		47	13.6	NS	
6	NS	NS		20	NS	NS		34	NS	10.3		48	23.1	1.9	12.2
7	NS	2.4		21	NS	NS		35	NS	NS		49	NS	NS	
8	200	4.0	50	22	NS	.4		36	NS	NS		50	NS	NS	
9	NS	NS		23	18.4	NS		37	30.3	NS		51	16.5	1.0	16.5
10	NS	NS		24	NS	1.4		38	NS	1.3		52	16.4	1.4	11.7
11	NS	NS		25	NS	1.1		39	NS	NS		53	NS	NS	
12	NS	5.5		26	NS	2.3		40	6.2	NS		54	NS	NS	
13	NS	1.7		27	NS	NS		41	14.9	1.4	10.6	55	NS	1.8	
14	117	3.2	36.6	28	69.2	1.4	49.4	42	NS	NS		56	NS	.2	

[a] Reduction factor = $\frac{\text{Cobalt-60 activity—1966 survey}}{\text{Cobalt-60 activity—1972 survey}}$

NS, no sample from this location.

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Table 3. Results of fish analysis, Groton, Conn. harbor survey, July 1972

Identification	Specific gamma activity (pCi/kg wet weight)	
Lobster	^{40}K	1,658 ± 13%
Lobster	^{95}Zr-Nb	43 ± 33%
	^{40}K	1,352 ± 16%
Bottom feeders	^{40}K	2,720 ± 7%
Flounder	^{40}K	2,567 ± 7%

Table 4. Results of vegetation analysis, Groton, Conn. harbor survey, July 1972

Sample identification	Specific gamma activity (pCi/kg dry weight)	
GV-36 (from piling at Electric Boat)	^{137}Cs	212 ± 37%
	^{95}Zr-Nb	848 ± 9%
	^{228}Th	194 ± 87%
	^{40}K	30,318 ± 4%
GV-17 (from location 57)	^{106}Ru	461 ± 69%
	^{137}Cs	77 ± 97%
	^{95}Zr-Nb	624 ± 13%
	^{228}Th	173 ± 72%
	^{60}Co	169 ± 43%
	^{40}K	24,041 ± 4%
GV-57 (from piling of State Pier)	^{106}Ru	844 ± 41%
	^{95}Zr-Nb	755 ± 10%
	^{228}Th	213 ± 63%
	^{60}Co	336 ± 24%
	^{40}K	24,855 ± 4%
GV-54 (from piling on Pier 16 in Sub Base)	^{144}Ce	3,891 ± 10%
	^{106}Ru	12,887 ± 0.6%
	^{95}Zr-Nb	7,071 ± 1%
	^{40}K	8,410 ± 15%

Water samples collected in the harbor area and from the Groton and New London municipal water supplies showed no activity other than natural potassium-40 which was detectable in the harbor water samples. Data from analysis of water samples are in table 5.

Table 5. Results of water analysis, Groton, Conn. harbor survey, July 1972

Location[a]	Gamma scan 3.5 liter geometry (pCi/liter)		Gamma scan 4 liters evaporated to 40 ml geometry (pCi/liter)[b]	
GW-1 Location 1	^{40}K	64 ± 56%	^{40}K	58 ± 50%
GW-2 Location 2	^{40}K	99 ± 37%	^{40}K	76 ± 23%
GW-58 New London Municipal Supply		ND		ND
GW-59 Groton Municipal Supply		ND		ND
GW-11 Location 11	^{40}K	173 ± 22%	^{40}K	134 ± 20%
GW-40 Location 40	^{40}K	193 ± 20%	^{40}K	110 ± 25%

[a] See figures 1–4 for location details.

[b] The error expressed is the percentage of the 2-sigma counting error for a normal distribution.

ND, nondetectable.

Core samples were taken at 10 locations to determine the vertical distribution of radioactivity in the sediment. Data from the analysis of these samples were presented in table 6.

The results of core samples taken from the State Pier area, the Submarine Base, and at Electric Boat near piers C and D show that the principal cobalt-60 radioactivity is to be found at a depth of 15 to 20 cm in the sediment. Most of the activity in the top few centimeters in these areas is due to natural potassium-40 and thorium as well as typical fallout radionuclides.

The results of analyses of core samples from locations 31 and 34 in the South Yard at Electric Boat show that the majority of cobalt-60 radioactivity was in the upper 13 cm of sedi-

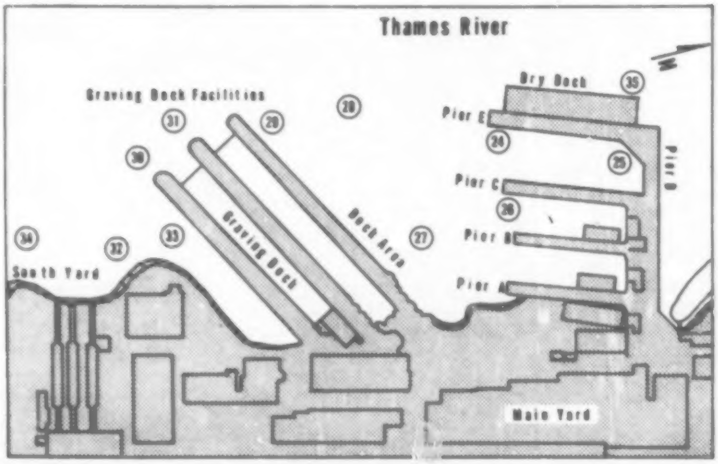

Figure 4. Electric boat detail—sampling locations

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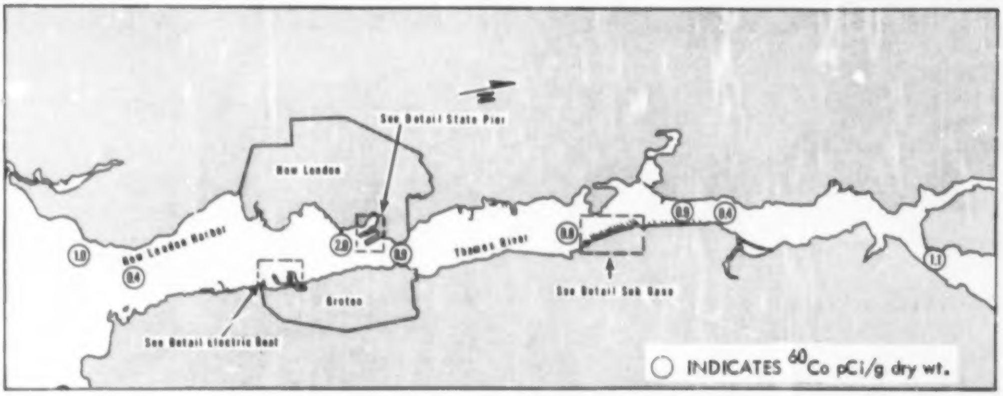

Figure 5. Thames river, New London harbor and data

Table 6. Results of core samples,[a] Groton, Conn. harbor survey, July 1972

Sample identification[b]	Depth below sediment-water interface (cm)	Cobalt-60 (pCi/g dry)
GC-8, location 8	2.5	[c] 9.3 ± 10%
	5.1	2.5 ± 24%
	7.6	2.4 ± 18%
	10	3.2 ± 19%
	13	5.9 ± 12%
	15	5.1 ± 13%
	18	25.1 ± 5%
	20	297.3 ± 1%
GC-12, location 12	2.5	ND
	5.1	.8 ± 85%
	7.6	2.2 ± 27%
	10	1.6 ± 32%
	13	1.5 ± 28%
	15	17.1 ± 5%
	18	4.3 ± 14%
	20	7.7 ± 10%
	23	50.5 ± 3%
	25	254.6 ± 2%
GC-14, location 14	2.5	3.2 ± 38%
	5.1	8.0 ± 10%
	7.6	1.4 ± 48%
	10	3.3 ± 21%
	13	2.7 ± 22%
	15	1.0 ± 30%
	18	2.6 ± 23%
	20	2.2 ± 25%
	23	4.7 ± 15%
	25	7.6 ± 10%
	28	10.8 ± 7%
	30	.7 ± 68%
	33	1.3 ± 44%
GC-25, location 25	2.5	1.0 ± 57%
	5.1	1.3 ± 42%
	7.6	.8 ± 66%
	10	.7 ± 73%
	13	2.8 ± 19%
	15	13.4 ± 6%
	18	21.5 ± 4%
	20	28.8 ± 4%
	23	[illegible] ± 53%
	25	8[illegible] ± 10%
GC-26, location 26	2.5	ND
	5.1	1.1 ± 61%
	7.6	2.2 ± 29%
	10	1.2 ± 42%
	13	6.4 ± 11%
	15	27.1 ± 4%
	18	73.2 ± 2%
	20	7.8 ± 9%
	23	14.4 ± 6%
	25	36.9 ± 3%
GC-31, location 31	2.5	2.7 ± 17%
	5.1	4.6 ± 15%
	7.6	2.1 ± 32%
	10	15.8 ± 6%
	13	36.9 ± 3%
	15	1.6 ± 85%
GC-31, location 31	18	1.2 ± 39%
	20	2.6 ± 22%
	23	1.5 ± 26%
	25	1.9 ± 21%
	28	2.1 ± 19%
	30	4.3 ± 10%
	33	.8 ± 43%
GC-34, location 34	2.5	6.3 ± 9%
	5.1	7.0 ± 9%
	7.6	2.2 ± 35%
	10	.6 ± 93%
	13	ND
	15	.5 ± 76%
GC-43, location 43	2.5	ND
	5.1	ND
	7.6	.7 ± 96%
	10	ND
	13	1.1 ± 52%
	15	2.0 ± 29%
	18	5.8 ± 13%
	20	13.8 ± 6%
	23	3.9 ± 19%
GC-45, location 45	2.5	ND
	5.1	ND
	7.6	1.2 ± 73%
	10	ND
	13	.9 ± 81%
	15	2.6 ± 30%
	18	3.5 ± 22%
	20	1.6 ± 42%
	23	.5 ± 76%
	25	1.7 ± 40%
	28	3.2 ± 22%
	30	2.3 ± 28%
GC-48, location 48	2.5	ND
	5.1	ND
	7.6	ND
	10	ND
	13	2.2 ± 55%
	15	ND
	18	ND
	20	3.2 ± 39%
	23	ND
	25	.9 ± 76%
	28	ND
	30	2.8 ± 25%
	33	1.3 ± 43%
	36	ND
	38	.5 ± 83%
	41	2.8 ± 19%
	43	.5 ± 99%
	4[illegible]	.9 ± 66%

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[a] Analysis of samples for potassium-40, zinc-65, zirconium-niobium-95, ruthenium-106, cesium-137, cerium-144, bismuth-214, and thorium-232 indicated levels of activity which were consistent with natural background and fallout from weapons testing.

[b] See figures 1-4 for location details.

[c] The error expressed is the percentage of the 2-sigma counting error for a normal distribution.

ND, nondetectable.

ment. This apparently is due to redistribution of the upper layers of sediment due to changing current in the South Yard.[5]

Table 7 shows a comparison of the cobalt-60 activity in the top 10 cm of the core samples with that from the dredge samples taken at the same locations. The dredge used to collect sediment samples also was sampling approximately the top 10 cm.

With three exceptions (locations 12, 31, and 34, table 7), the data agree quite well. At locations 31 and 34 (table 7), if it could be assumed that the dredge sampled only the top 5 cm instead of the top 10 cm, data from these locations would be in much better agreement. If little silting had taken place at these locations (as speculated previously), the absence of this soft material would cause the dredge to dig less deeply into a firm bottom and thus collect a shallow sample.

Table 7. Comparison of dredge samples with top 10 cm of core samples from same location

Location	Average cobalt-60 activity in core sample (pCi/g dry weight)		Cobalt-60 activity in dredge sample (pCi/g dry weight)
	Top 10 cm	Top 5 cm	
8	4.4		4.0
12	1.5		5.5
14	4.0		3.2
25	1.0		1.1
26	1.5		2.3
31	6.3	3.7	2.5
34	4.0	6.7	10.3
43	.7		1.3
45	1.2		1.5
48	2.2		1.9

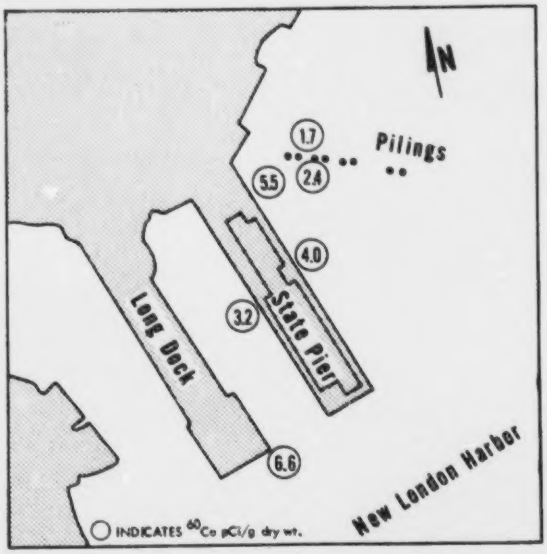
N
1.7
Pilings
5.5
2.4
4.0
3.2
Long Dock
State Pier
6.6
New London Harbor
○ INDICATES ^{60}Co pCi/g dry wt.

Figure 6. State pier detail and data

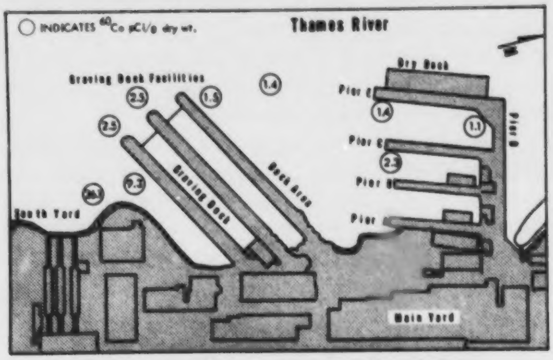
○ INDICATES ^{60}Co pCi/g dry wt.
Thames River
Graving Dock Facilities
2.5
2.5
1.5
1.4
Dry Dock
1.4
1.1
2.3
Graving Dock
Dock Area
South Yard
Main Yard

Figure 7. Electric Boat detail and data

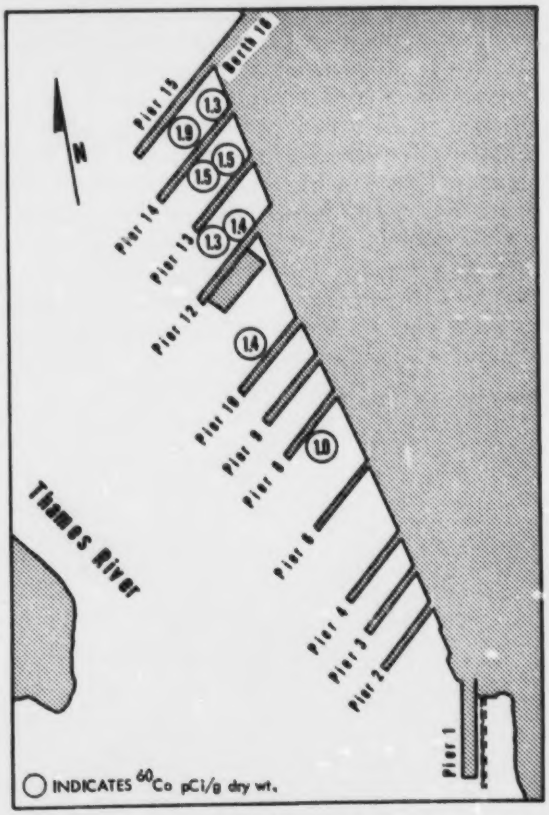
Berth 16
Pier 15
1.3
1.9
N
1.5
1.5
Pier 14
1.3
1.4
Pier 13
Pier 12
1.4
Pier 10
Pier 9
1.0
Pier 8
Pier 6
Thames River
Pier 4
Pier 3
Pier 2
Pier 1
○ INDICATES ^{60}Co pCi/g dry wt.

Figure 8. Submarine base detail and data

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[5] Personal communication, Naval Ship Systems Command.

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Conclusions

As a result of the 1972 survey the following conclusions could be drawn:

1. The data of this report show that cobalt-60 activity levels in Thames River sediments in the harbor at Groton-New London, Conn., have decreased from 1966 to 1972 by an average factor of 33 for the areas sampled. This decrease is due to a reduction in the amount of radioactive waste discharged, radioactive decay and natural sedimentation.

2. The State Pier area and the South Yard area at Electric Boat have the highest cobalt-60 activity levels found in the 1972 survey as was the case in the 1966 survey.

3. No evidence was found of cobalt-60 activity in areas where it was absent in the 1966 survey.

4. The routine environmental radiological monitoring program conducted by the NAVSHIPS in the Groton-New London area is adequate to effectively assess the radiological impact of nuclear ships and their support facilities in that area. This conclusion is based on an analysis of the sampling frequency and the locations and number of samples taken. Further, data from their recent report (*2*) show that the cobalt-60 activity levels in the river sediment are decreasing.

5. The results of this survey indicate that nuclear-powered vessel operations have not resulted in activity levels which could contribute a significant radiation exposure to the public. This conclusion is based on the fact that:

   a. activity is located principally in harbor sediment and not in fish or lobster,

   b. levels of radioactivity are quite low compared to the Atomic Energy Commission standards,

   c. there is no commercial fishing in the harbor, and

   d. no activity other than natural radioactivity was found in the harbor and drinking water.

The continuation of current waste discharge practices and the Navy routine monitoring program should be sufficient to assure continued absence of significant public exposure for routine nuclear ship operations.

REFERENCES

(*1*) CAHILL, D. F., W. D. BREAKFIELD, and D. C. McCURRY. Radiological survey of Thames River, Connecticut, and environs, July–August 1966. Southeastern Radiological Health Laboratory Technical Report.

(*2*) MILES, M. E., G. L. SJOBLOM, and R. D. BURKE. Environmental monitoring and disposal of radioactive wastes from U.S. Naval nuclear-powered ships and their support facilities, 1971. Radiat Data Rep 13: 469–478 (September 1972).

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SECTION I. MILK AND FOOD

Milk Surveillance, July 1973

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption readily can be obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 65 sampling stations: 63 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 16 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—7 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare—16 sampling stations

The sampling locations that make up the networks reporting presently in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radio-

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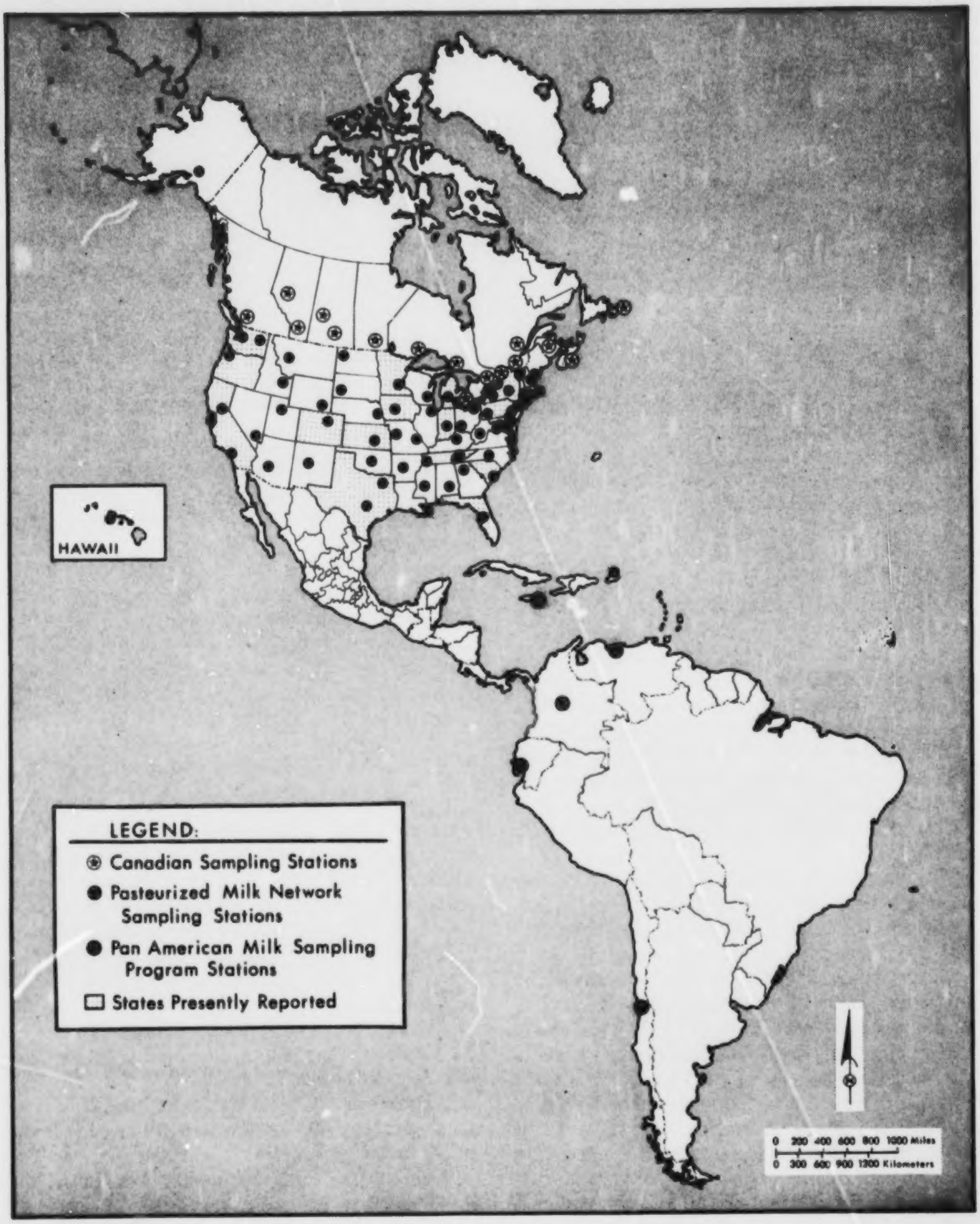
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
● Pan American Milk Sampling Program Stations
☐ States Presently Reported
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers

Figure 1. Milk sampling networks in the Western Hemisphere

strontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, first it was necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been previously outlined (*4*).

The most recent study was conducted during June 1972, with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 18 laboratories producing data for the networks reporting in *Radiation Data and Reports*, 14 participated in the study.

The accuracy results of this study for these 14 laboratories are shown in table 1. The accuracy of the cesium-137 measurements continues to be excellent as in previous experiments. However, both the accuracy and precision need to be improved for iodine-131, strontium-89, and strontium-90 which could probably be accomplished through recalibration.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels.

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration		Number of laboratories in each category				Experimental 2σ error (pCi/liter)
		Acceptable[a]	Warning level[b]	Unacceptable[c]	Total	
Iodine-131	(96 or 99 pCi/liter)	7 (58%)	1 (8%)	4 (33%)	12	6
	(438 or 484 pCi/liter)	11 (85%)	0	2 (15%)	13	25 or 28
Cesium-137	(53 or 54 pCi/liter)	11 (92%)	0	1 (8%)	12	6
	(295 or 303 pCi/liter)	11 (85%)	2 (15%)	0	13	17
Strontium-89	(29 or 30 pCi/liter)	9 (82%)	0	2 (18%)	11	6
	(197 or 201 pCi/liter)	3 (33%)	1 (11%)	5 (56%)	9	11 or 12
Strontium-90	(32.1 or 32.4 pCi/liter)	4 (33%)	4 (33%)	4 (33%)	12	1.9
	(150.5 or 151.2 pCi/liter)	6 (55%)	0	5 (45%)	11	8.7

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and generally is increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*6*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sampling determinations. The treatment of measurements equal to or below those practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range also has been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the United States data on radioactivity in milk in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the February 1973 issue of *Radiation Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are reported routinely in *Radiation Data and Reports*. The relationship between the PMN stations and the State stations is shown in figure 2. The first column in table 2 under each of the reported radionuclides gives the

Table 2. Concentrations of radionuclides in milk for July 1973 and 12-month period August 1972 through July 1973

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:						
Ala:	Montgomery [c]	P	3	5	12 (2)	5
Alaska:	Palmer [c]	P	3	4	12	1
Ariz:	Phoenix [c]	P	0	0	0	0
Ark:	Little Rock [c]	P	12	10	0	2
Calif:	Los Angeles [c]	P	0	0	0	0
	Sacramento [c]	P	0	1	0	0
	San Francisco [c]	P	0	0	0	0
	Del Norte	P	10	11	0	6
	Fresno	P	0	1	0	2
	Humboldt	P	0	3	0	1
	Los Angeles	P	0	1	0	1
	Mendocino	P	2	2	0	3
	Sacramento	P	0	2	0	3
	San Diego	P	0	1	0	3
	Santa Clara	P	2	2	0	2
	Shasta	P	2	2	0	4
	Sonoma	P	0	2	0	2
Colo:	Denver [c]	P	NA	2	0	0
	East	R	NS	NA	NS	14
	Northeast	R	NA	NA	[d]0 (2)	1
	Northwest	R	NS	NA	NS	2
	South Central	R	NS	NS	NS	NS
	Southeast	R	NS	NA	NS	0
	Southwest	R	NA	NA	[d]0	2
	West	R	NA	NA	[d]0	0
Conn:	Hartford [c]	P	4	4	0	4
	Central	P				
Del:	Wilmington [c]	P	8	6	0	5
D.C:	Washingtop [c]	P	4	4	0	2
Fla:	Tampa [c]	P	4	4	34	30
	Central	R	5	5	28	33
	North	R	4	6	10	13
	Northeast	R	NA	6	25	31
	Southeast	R	4	5	41	45
	Tampa Bay area	P	3	5	31	31
	West	R	7	8	14	8
Ga:	Atlanta [c]	P	4	6	9 (3)	7
Hawaii:	Honolulu [c]	P	0	1	0	0
Idaho:	Idaho Falls [c]	P	3	3	0	0
Ill:	Chicago [c]	P	5	5	0	2
Ind:	Indianapolis [c]	P	5	5	7 (2)	3
	Central	P	7	7	0	8
	Northeast	P	6	5	10	8
	Northwest	P	10	8	0	9
	Southeast	P	9	7	0	5
	Southwest	P	10	7	10	9
Iowa:	Des Moines [c]	P	4	5	0 (3)	0
	Des Moines	P	5	6	0	0
	Iowa City	P	5 (3)	5	0 (3)	0
	LeMars	P	4	4	0	2
	Little Cedar	P	7	7	0	2
Kans:	Wichita [c]	P	6	5	0	0
	Coffeyville	P	8	8	3	8
	Dodge City	P	5	4	8	5
	Falls City, Nebr	R	5	3	6	7
	Hays	P	7	9	1	6
	Kansas City	P	5	8	5	8
	Topeka	P	6	7	7	4
	Wichita	P	6	8	5	10
Ky:	Louisville [c]	P	5	5	0	1
La:	New Orleans [c]	P	8	9	7 (2)	1
Maine:	Portland [c]	P	8	6	20	19
Md:	Baltimore [c]	P	8	6	12	6
Mass:	Boston [c]	P	8	7	25	16
Mich:	Detroit [c]	P	6	6	0	3
	Grand Rapids [c]	P	7	8	0	1
	Bay City	P	9	7	0	0
	Charlevoix	P	3	6	3 (4)	3
	Detroit	P	0	4	0	1
	Grand Rapids	P	7	5	0	1
	Lansing	P	11	6	8 (2)	4
	Marquette	P	18 (2)	7	16 (2)	10
	Monroe	P	17	6	0 (2)	0
	South Haven	P	5	7	8 (5)	4
Minn:	Minneapolis [c]	P	7	7	0 (2)	6
	Bemidji	P	7	7	0	13
	Duluth	P	18	15	20	21
	Fergus Falls	P	4	7	0	0
	Little Falls	P	26	24	67	28
	Mankato	P	4	5	0	0
	Marshall	P	4	4	0	0

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for July 1973 and 12-month period August 1972 through July 1973—continued

Sampling location		Type of sample ᵃ	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average ᵇ	12-month average	Monthly average ᵇ	12-month average
Minn:	Minneapolis	P	10	9	0	11
	Rochester	P	8	8	0	0
Miss:	Jackson ᵉ	P	8	8	16	7
Mo:	Kansas City ᵉ	P	4	4	0	0
	St. Louis ᵉ	P	8	6	11	1
Mont:	Helena ᵉ	P	0	2	0	0
Nebr:	Omaha ᵉ	P	0	3	0	0
Nev:	Las Vegas ᵉ	P	8	3	0	0
N.H:	Manchester ᵉ	P	9	7	15	12
N.J:	Trenton ᵉ	P	4	6	0	6
N. Mex:	Albuquerque ᵉ	P	0	0	0	0
N.Y:	Buffalo ᵉ	P	6	4	0	3
	New York City ᵉ	P	4	6	12	5
	Syracuse ᵉ	P	6	6	11	2
	Albany	P	5 (5)	4	0 (5)	0
	Buffalo	P	5	4	0	0
	Massena	P	12	6	25	0
	New York City	P	15	7	0	0
	Syracuse	P	4	5	0	0
N. C:	Charlotte ᵉ	P	9	7	13	7
N. Dak:	Minot ᵉ	P	8	7	6 (2)	0
Ohio:	Cincinnati ᵉ	P	6	5	0 (2)	2
	Cleveland ᵉ	P	7	6	8 (3)	3
Okla:	Oklahoma City ᵉ	P	2	3	0	0
Oreg:	Portland ᵉ	P	0	4	16 (2)	1
	Baker	P	NA		NA	
	Coos Bay	P	NA		NA	
	Eugene	P	NA		NA	
	Medford	P	NA		NA	
	Portland composite	P	NA		NA	
	Portland local	P	NA		NA	
	Redmond	P	NA		NA	
	Tillamook	R	NA		NA	
Pa:	Philadelphia ᵉ	P	5	5	0 (3)	2
	Pittsburgh ᵉ	P	10	8	7 (2)	5
	Dauphin	P	6	5	0	2
	Erie	P	8	7	4	3
	Philadelphia	P	6	4	0	3
	Pittsburgh	P	6	6	0	2
R. I:	Providence ᵉ	P	4	5	13	8
S. C:	Charleston ᵉ	P	5	7	19	9
	Chapin	R	NS	8	NS	11
	Clemson	R	9	7	21	6
	Columbia	R	NS	7	NS	10
	Fairfield	R	NS	7	NS	13
	Hartsville-02	R	7	6	8	12
	Hartsville-03	R	16	17	14	16
	Lee County	R	8	8	14	17
	Oconee County	R	NS	8	NS	7
	Pickens	R	9	7	10	5
	Williston	R	NS	7	NS	15
	Winnsboro	R	NS	8	NS	24
S. Dak:	Rapid City ᵉ	P	8	5	13	1
Tenn:	Chattanooga ᵉ	P	6	6	0	5
	Knoxville ᵉ	P	NS		NS	
	Memphis ᵉ	P	6	6	0	2
	Chattanooga	P	9	8	12	6
	Clinton	R	6	7	0	0
	Fayetteville	R	6	7	0 (3)	4
	Kingston	R	6	7	0 (2)	0
	Knoxville	P	5	5	0 (3)	2
	Lawrenceburg	R	NS	6	NS	5
	Nashville	P	5	6	0 (2)	2
	Pulaski	R	7	6	0 (2)	3
	Sequoyah	R	NS	7	NS	8
Tex:	Austin ᵉ	P	0	0	0	0
	Dallas ᵉ	P	3	4	0	0
	Amarillo	R	NA		NA	
	Corpus Christi	R	NA		NA	
	El Paso	R	NA		NA	
	Fort Worth	R	NA		NA	
	Harlingen	R	NA		NA	
	Houston	R	NA		NA	
	Lubbock	R	NA		NA	
	Midland	R	NA		NA	
	San Antonio	R	NA		NA	
	Texarkana	R	NA		NA	
	Uvalde	R	NA		NA	
	Wichita Falls	R	NA		NA	
Utah:	Salt Lake City ᵉ	P	0	2	0	1
Vt:	Burlington ᵉ	P	5	5	7 (2)	3
Va:	Norfolk ᵉ	P	6	5	0	3

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for July 1973 and 12-month period August 1972 through July 1973—continued

Sampling location	Type of sample [a]	Radionuclide concentration (pCi/liter)			
		Strontium-90		Cesium-137	
		Monthly average [b]	12-month average	Monthly average [b]	12-month average
Wash: Seattle [c]	P	0	2	0 (3)	1
Spokane [c]	P	4	4	0	0
Benton County	R				
Franklin County	R				
Longview	R				
Sandpoint, Idaho	R				
Skagit County	R				
W. Va: Charleston [c]	P	8	6	0	3
Wisc: Milwaukee [c]	P	3	5	12	3
Wyo: Laramie [c]	P	0	1	11	1
CANADA:					
Alberta: Calgary	P	NA		7	10
Edmonton	P	NA		9	14
British Columbia: Vancouver	P	NA		12	15
Manitoba: Winnipeg	P	NA		10	11
New Brunswick: Moncton	P	NA		9	9
Newfoundland: St. John's	P	NA		NS	
Nova Scotia: Halifax	P	NA		NS	
Ontario: Ottawa	P	NA		6	7
Sault Ste. Marie	P	NA		17	17
Thunder Bay	P	NA		NS	
Toronto	P	NA		5	7
Windsor	P	NA		6	7
Quebec: Montreal	P	NA		5	7
Quebec	P	NA		15	16
Saskatchewan: Regina	P	NA		3	8
Saskatoon	P	NA		4	8
CENTRAL AND SOUTH AMERICA:					
Canal Zone: Cristobal [c]	P	NS	0	NS	10
Chile: Santiago	P	3	1	0	0
Colombia: Bogota	P	NS	0	NS	0
Ecuador: Guayaquil	P	0	0	0	0
Jamaica: Kingston	P	NS	2	NS	41
Puerto Rico: San Juan [c]	P	3	1	0	2
Venezuela: Caracas	P	NS	0	NS	2
PMN network average [e]		5	5	5	3

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a month period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] The practical reporting level for this network differs from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:
Cesium-137: Colorado—25 pCi/liter; Oregon—15 pCi/liter.

[e] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample.

monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropri-

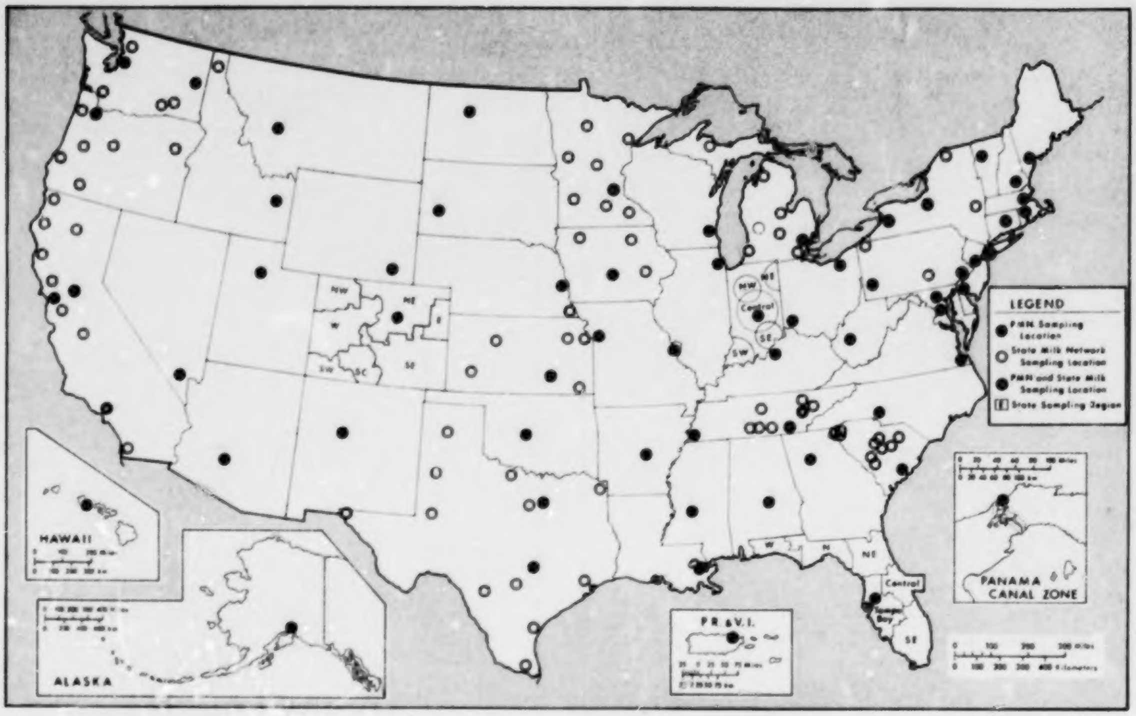
LEGEND
PMN Sampling Location
State Milk Network Sampling Location
PMN and State Milk Sampling Location
State Sampling Region
HAWAII
ALASKA
P.R. & V.I.
PANAMA CANAL ZONE
NW
NE
W
E
SW
SC
SE
MW
Central
N
Tampa Bay

Figure 2. State and PMN sampling stations in the United States

ate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for July 1973 and the 12-month period, August 1972 to July 1973. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from table 2 since levels at all of the stations for July 1973 were below the respective practical reporting levels.

Strontium-89 and iodine-131 results for individual samples were all below the respective practical reporting levels. Barium-140 results for individual samples were all below the practical reporting level with the following exception: Kansas, Coffeyville (State) 11 pCi/liter.

Strontium-90 monthly averages ranged from 0 to 26 pCi/liter in the United States for July 1973 and the highest 12-month average was 24 pCi/liter (Little Falls, Minn.) representing 12.0 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 67 pCi/liter in the United States for July 1973, and the highest 12-month average was 45 pCi/liter (Southeast Florida) representing 1.3 percent of the value derived from the recommendations given in the Federal Radiation Council report.

The Office of Radiation Programs is in the process of modifying the milk program to make it more responsive to potential sources of environmental radioactivity. These changes will be reflected in future articles.

Acknowledgment

Appreciation is expressed to the personnel of the following agencies who provide data from their milk surveillance networks:

Environmental Control Component
Radiologic Health Section
California Department of Health

Radiation Protection Division
Canadian Department of National
Health and Welfare

Radiological Health Section
Division of Occupational and
Radiological Health
Colorado Department of Health

Department of Environmental Protection
Department of Health Laboratory Division
State of Connecticut

Radiological and Occupational
Health Section
Department of Health and
Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of
Environmental Conservation

Environmental Radiation Surveillance
Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Division of Radiological Health
South Carolina State Board of Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of
Social and Health Services

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(*1*) CAMPBELL, J. E., G. K. MURTHY, A. S. GOLDIN, H. B. ROBINSON, C. P. STRAUB, F. J. WEBER and K. H. LEWIS. The occurrence of strontium-90, iodine-131, and other radionuclides in milk, May 1957 through April 1958. Amer J Pub Health 49:225 (February 1969).

(*2*) U.S. ATOMIC ENERGY COMMISSION, DIVISION OF ISOTOPES DEVELOPMENT. Chart of the Nuclides, Tenth Edition revised to December 1968. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*3*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk surveillance. Radiol Health Data Rep 9:730–746 (December 1968).

(*4*) ROSENSTEIN, M. and A. S. GOLDIN. Statistical technics for quality control of environmental radioassay. Health Lab Sci 2:93 (April 1965).

(5) BARATTA, E. J. and F. E. KNOWLES, JR. Interlaboratory study of iodine-131, cesium-137, strontium-89, and strontium-90 measurements in milk, June 1972, Technical experiment 72 MKAQ–1. Analytical Quality Control Service, Office of Radiation Programs, EPA, Washington, D.C. 20460 (December 1972).

(*6*) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).

Milk Surveillance Network, June–July 1973

National Environmental Research Center-Las Vegas, Environmental Protection Agency

The Milk Surveillance Network,[1] operated by the National Environmental Research Center—Las Vegas (NERC-LV) consists of 24 routine and two alternate sampling locations (figure 1) situated in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing conducted by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site (NTS).

In the event of a release of radioactivity from the NTS, special sampling within the affected

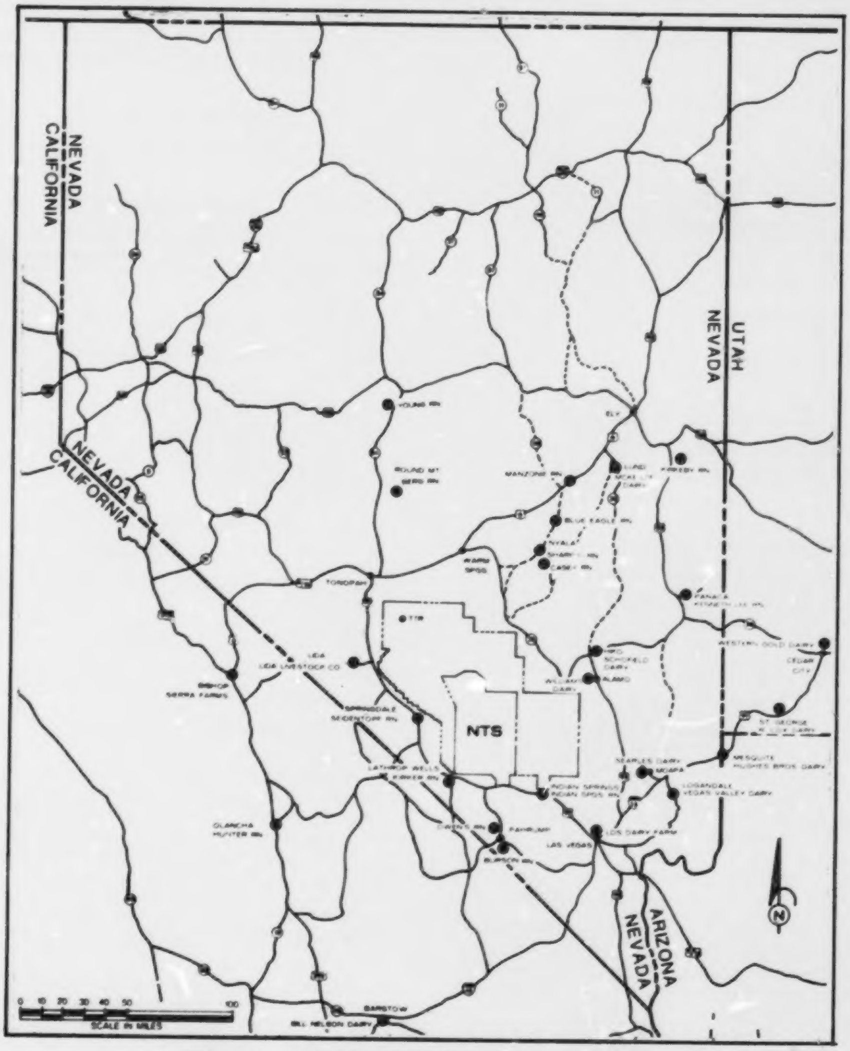
NEVADA
CALIFORNIA
UTAH
NEVADA
ELY
YOUNG RN.
ROUND MT
BERG RN.
MANZONI RN.
BLUE EAGLE RN.
NYALA
CASEY RN.
WARM SPGS.
TONOPAH
TTR
PANACA
HIKO
SCHOFIELD DAIRY
ALAMO
WILLIAMS DAIRY
WESTERN GOLD DAIRY
CEDAR CITY
ST GEORGE
LIDA
LIDA LIVESTOCK CO.
BISHOP
SIERRA FARMS
SPRINGDALE
NTS
LATHROP WELLS
INDIAN SPRINGS
SEARLES DAIRY
MOAPA
MESQUITE
HUGHES BROS DAIRY
LOGANDALE
VEGAS VALLEY DAIRY
LDS DAIRY FARM
LAS VEGAS
PAHRUMP
OLANCHA
HUNTER RN.
ARIZONA
NEVADA
N
BARSTOW
BILL NELSON DAIRY
0 10 20 30 40 50 100
SCALE IN MILES

Figure 1. NERC-LV Milk Surveillance Network

area is conducted to determine radionuclide concentrations. Additional milk sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and analytical procedures was included with the milk results reported in the July 1973 issue of *Radiation Data and Reports*.

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[1] This network is operated under a Memorandum of Understanding (No. AT(26–1)–539) with the Nevada Operations Office, U.S. AEC, Las Vegas, Nev.

Results

The analytical results of all milk samples collected in June and July 1973 by NERC-LV surveillance programs are listed in tables 1 and 2. With the exception of cesium-137 at levels near the minimum detectable activity (MDA) of 10 pCi/liter, no gamma-emitting fission products were identified by gamma spectrometry in any

Table 1. Milk surveillance results, June 1973

Location	Date collected (June 1973)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)			
			Cesium-137	Strontium-89	Strontium-90	Tritium
California:						
Bishop:						
Sierra Farms	14	11	<10	NA	NA	NA
Hinkley:						
Bill Nelson Dairy	13	12	<10	NA	NA	NA
Olancha:						
Hunter Ranch	13	13	<10	NA	NA	NA
Nevada:						
Alamo:						
Williams Dairy	11	12	<10	NA	NA	NA
Austin:						
Young's Ranch	13	13	<10	NA	NA	770±250
Currant:						
Blue Eagle Ranch	20	13	<100	NA	NA	NA
Manzonie Ranch	20	13	<10	NA	NA	NA
Hiko:						
Schofield Dairy	11	12	<10	NA	NA	<250
Indian Springs:						
Indian Springs Ranch	NS					
Las Vegas:						
LDS Dairy Farms	14	12	<10	NA	NA	<250
Lathrop Wells:						
Kirker Ranch	12	13	<10	NA	NA	NA
Lida:						
Lida Livestock Company	NS					
Logandale:						
Vegas Valley Dairy	11	12	<10	NA	NA	NA
Lund:						
McKenzie Dairy	13	12	<10	NA	NA	<250
Mesquite:						
Hughes Bros. Dairy	12	12	<10	NA	NA	<250
Moapa:						
Searles Dairy	12	12	<10	NA	NA	NA
Nyala:						
Sharp's Ranch	12	13	[c] <100	NA	NA	<250
Pahrump:						
Owens Ranch	13	13	<10	NA	NA	NA
Panaca:						
Kenneth Lee Ranch	12	13	<10	NA	NA	NA
Round Mountain:						
Berg Ranch	13	13	<10	NA	NA	NA
Shoshone:						
Kirkeby Ranch	17	13	<10	NA	NA	NA
Springdale:						
Seidentopf Ranch	13	13	<10	NA	NA	NA
Utah:						
Cedar City:						
Western Gold Dairy	12	12	<10	NA	NA	NA
St. George:						
R. Cox Dairy	13	12	<10	NA	NA	NA

[a] 11—Pasteurized milk.
12—Raw milk from Grade A producer(s).
13—Raw milk from family cow(s).
[b] Two-sigma counting error provided when available.
[c] Small sample size increased minimum detectable activity.
NA, no analysis.
NS, no sample.

Table 2. Milk surveillance results, July 1973

Location	Date collected (July 1973)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)			
			Cesium-137	Strontium-89	Strontium-90	Tritium
California:						
Bishop:						
Sierra Farms	19	11	<10	<3.0	<2.0	NA
Hinkley:						
Bill Nelson Dairy	17	12	<10	<2.0	<1.4	NA
Olancha:						
Hunter Ranch	NS	13				
Nevada:						
Alamo:						
Williams Dairy	17	12	<10	<2.0	<1.5	NA
Austin:						
Young's Ranch	9	13	<10	<2.0	2.0±1.4	680±230
Currant:						
Blue Eagle Ranch	NS	13				
Manzonie Ranch	16	13	<10	<2.0	<1.3	NA
Hiko:						
Schofield Dairy	17	12	<10	<2.0	<1.3	<230
Indian Springs:						
Indian Springs Ranch	NS					
Las Vegas:						
LDS Dairy Farms	6	12	<10	<1.0	<1.0	<230
Lathrop Wells:						
Kirker Ranch	11	13	<10	<2.0	<1.1	NA
Lida:						
Lida Livestock Company	NS	13				
Logandale:						
Vegas Valley Dairy	2	12	<10	<2.0	<1.2	NA
Lund:						
McKenzie Dairy	17	12	<10	<2.0	1.9±1.4	<230
Mesquite:						
Hughes Bros. Dairy	2	12	<10	<2.0	<1.1	<230
Moapa:						
Searles Dairy	2	12	<10	<2.0	2.4±1.3	NA
Nyala:						
Sharp's Ranch	10	13	[c]<100	<2.0	2.3±1.3	<220
Pahrump:						
Owens Ranch	12	13	<10	<2.0	<1.1	NA
Panaca:						
Kenneth Lee Ranch	18	13	<10	<2.0	2.5±1.4	NA
Round Mountain:						
Berg Ranch	9	13	<10	<2.0	3.3±1.5	NA
Shoshone:						
Kirkeby Ranch	15	13	<10	<3.0	<2.3	NA
Springdale:						
Seidentopf Ranch	10	13	<10	<1.0	1.4±1.1	NA
Utah:						
Cedar City:						
Western Gold Dairy	3	12	<10	<2.0	<1.4	NA
St. George:						
R. Cox Dairy	3	12	<10	<2.0	1.4±1.2	NA

[a] 11—Pasteurized milk.
12—Raw milk from Grade A producer(s).
13—Raw milk from family cow(s).
[b] Two-sigma counting error provided when available.
[c] Small sample size increased minimum detectable activity.
NA, no analysis.
NS, no sample.

of the samples collected in June. Levels of tritium near the MDA for this radionuclide (~200 pCi/liter) were also measured by liquid scintillation. The highest concentration of tritium during June was 770 ± 250 pCi/liter.

No gamma-emitting fission products were identified by gamma spectrometry in any of the samples collected in July. Levels of tritium and strontium-90 slightly above the MDA for these radionuclides (~200 pCi/liter and ~1 pCi/liter, respectively) were detected by liquid scintillation and radiochemistry procedures. The highest concentrations of these radionuclides during July were 680 ± 230 pCi–liter and 3.3 ± 1.5 pCi/liter, respectively.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	January–June 1971	December 1972
Radiostrontium in Milk	January–December 1971	November 1972
Strontium-90 in Tri-City Diets	January–December 1971	December 1972

Carbon-14 in Total Diet and Milk, 1972–1973

Office of Radiation Programs
Environmental Protection Agency

In July 1965, a program to determine the levels of carbon-14 and tritium in the total diet and milk in the United States was initiated by the Public Health Service. In December 1970, this program was transferred to the Office of Radiation Programs of the Environmental Protection Agency (EPA). Initially, monthly samples from each of the EPA Institutional Total Diet Sampling Network (ITDSN) and Pasteurized Milk Network (PMN) stations were composited and analyzed according to six arbitrarily selected regions: Northeast, South, Delta, Central, Southwest, and Northwest. Figure 1 shows the ITDSN and PMN sampling stations in each of the designated regions.

In January 1966, the program was modified to include selected stations in each of the previously mentioned regions plus Alaska and Hawaii. The nine geographically distributed sampling stations are: Palmer, Alaska; Honolulu, Hawaii; Idaho Falls, Idaho; Chicago, Ill.; New Orleans, La.; Boston, Mass.; Portland, Oreg.; and Charleston, S.C. Los Angeles, Calif., is not a PMN station, but a special milk sample is collected monthly for purposes of comparison with the routine ITDSN sample.

A 1-liter milk sample and a 2-kilogram food sample are sent to the National Environmental Research Center-Las Vegas for analysis. The milk and total diet samples analyzed represent the samples collected for that month.

The carbon-14 analyses are performed semiannually. The tritium analyses were discontinued in July 1969 because the results were only slightly above the limit of detectability and were less than 1 percent of the maximum permissible concentration for milk and food consumed by the general population.

The carbon-14 content is determined by combustion of the milk or food sample and collection and purification of the evolved carbon dioxide. The carbon dioxide is then converted to benzene and counted in a liquid scintillation spectrometer.

Results and discussion

The carbon-14 concentrations in total diet and milk are shown in table 1 as dpm/g C and pCi/kg or pCi/liter. This is the final data presentation of carbon-14 in total diet since the ITDSN was discontinued in June 1973, and a summary of the mean carbon-14 concentrations

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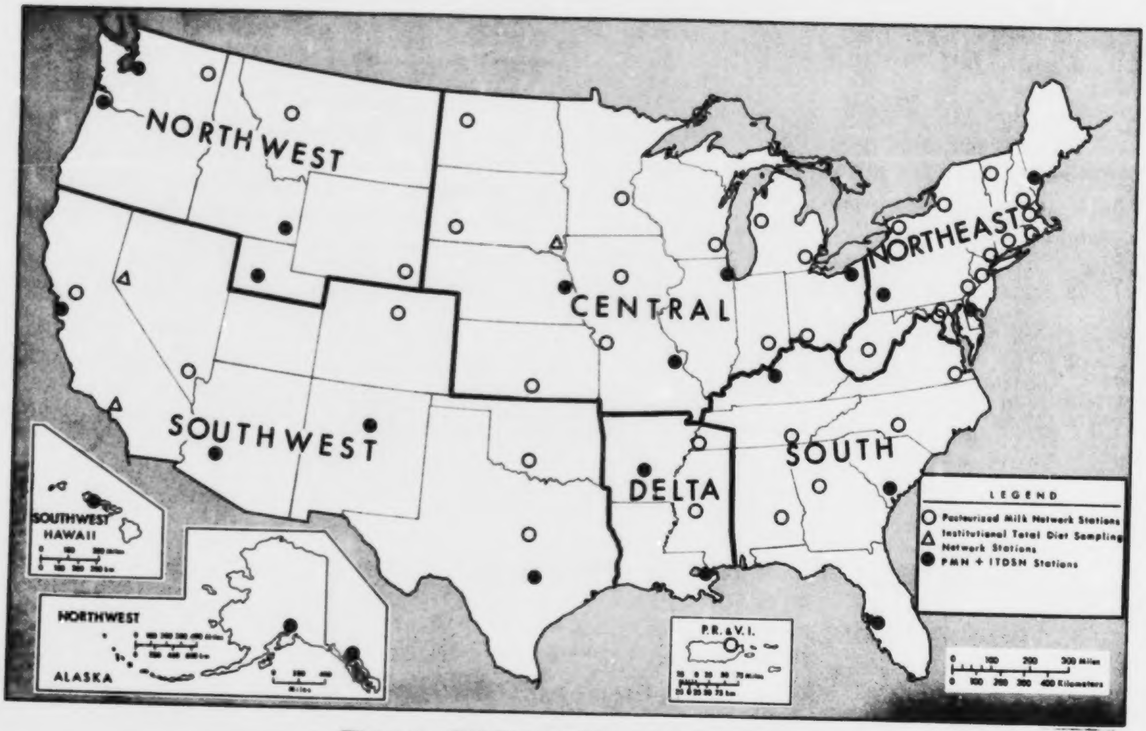
NORTHWEST
SOUTHWEST
CENTRAL
NORTHEAST
DELTA
SOUTH
SOUTHWEST HAWAII
NORTHWEST ALASKA
P.R. & V.I.
LEGEND
○ Pasteurized Milk Network Stations
△ Institutional Total Diet Sampling Network Stations
● PMN + ITDSN Stations
0 100 200 300 Miles
0 100 200 300 400 Kilometers

Figure 1. ITDSN and PMN sampling stations

Table 1. Carbon-14 in total diet and milk, 1972-1973

Location	Date collected	Total diet (dpm/g C ±2σ)	Total diet (pCi/kg ±2σ)	Milk (dpm/g C ±2σ)	Milk (pCi/liter ±2σ)
Alaska: Palmer	April 1972	NS	NS		
	Dec 1972	18.4±0.7	910±30	19.2±0.9	460±20
	Jan 1973			18.8± .8	470±20
	April 1973	NS	NS	16.0± .7	450±20
Calif: Los Angeles	April 1972	NS	NS		
	Oct 1972	NS	NS	16.6± .6	430±20
	Jan 1973			17.5± .6	480±20
	April 1973	NS	NS	16.9± .8	500±20
Hawaii: Honolulu	April 1972	14.6± .6	620±20		
	Oct 1972	15.6± .8	640±40	NS	NS
	Jan 1973			16.2± .7	410±20
	April 1973	16.1± .7	740±30	19.0± .7	650±20
Idaho: Idaho Falls	April 1972	14.0± .6	580±20	16.0± .5	540±20
	Jan 1973	16.6± .7	750±30	19.4± .7	490±20
	April 1973	NS	NS	14.8±1.0	380±30
Ill: Chicago	April 1972	18.8± .7	860±30	NS	NS
	Oct 1972	NS	NS	17.6± .6	610±20
	April 1973	NS	NS	NS	NS
La: New Orleans	April 1972	14.8± .7	690±30	NS	NS
	Oct 1972			13.8± .5	360±20
	Jan 1973	15.2± .7	700±30		
	April 1973	18.1± .6	460±30	NS	NS
Mass: Boston	April 1972	15.9± .5	720±30		
	Nov 1972			19.2± .8	390±10
	Jan 1973	15.4±1.0	560±40	15.9± .6	470±20
	April 1973				
	May 1973	18.9± .9	780±30	17.0± .7	510±20

Table 1. Carbon-14 in total diet and milk, 1972-1973—continued

Location		Date collected	Total diet		Milk	
			(dpm/g C ±2σ)	(pCi/kg ±2σ)	(dpm/g C ±2σ)	pCi/liter ±2)
Oreg:	Portland	April 1972	NS	NS	18.9 ± .8	490 ±20
		Oct 1972	20.0 ± .7	660 ±20		
		Jan 1973			17.8 ± .8	510 ±20
		April 1973	18.6 ± .7	710 ±30	16.4 ± .6	510 ±20
S.C:	Charleston	April 1972	19.8 ± .7	790 ±30	16.9 ±1.4	320 ±30
		Oct 1972	NS	NS	17.6 ± .6	510 ±20
		April 1973	NS	NS	19.4 ± .7	570 ±20

NS, no sample.

Table 2. Summary of the mean carbon-14 concentrations in total diet and milk for all stations

Date collected	Total diet[a]		Milk[a]	
	(dpm/g C)	(pCi/kg)	(dpm/g C)	(pCi/liter)
July-December 1965		1,120 (920-1,380)		570 (450- 760)
January-June 1966		1,100 (800-1,510)		610 (490- 710)
July-December 1966		1,200 (770-1,470)		555 (350- 690)
January-June 1967		1,290 (1,150-1,450)		680 (480-1,040)
July-December 1967		1,170 (1,130-1,450)		570 (390- 790)
January-June 1968		1,160 (1,020-1,280)		550 (390- 740)
July-December 1968		1,030 (770-1,170)		500 (360- 630)
January-June 1969		1,020 (850-1,160)		500 (460- 560)
July-December 1969		1,000 (880-1,140)		490 (460- 510)
January-June 1970		890 (780-1,040)		470 (460- 520)
July-December 1970		820 (780- 860)		430 (410- 470)
January-June 1971	17.23 (15.92-18.48)	800 (740- 860)	16.90 (15.07-18.37)	430 (380- 460)
July-December 1971	17.22 (15.35-18.27)	750 (670- 800)	15.85 (14.50-17.14)	390 (360- 420)
January-June 1972	16.3 (14.0 -19.8)	710 (530- 860)	17.8 (16.0 -19.2)	440 (320- 540)
July-December 1972	18.0 (15.6 -20.0)	740 (640- 910)	16.2 (13.8 -17.6)	490 (360- 610)
January-June 1973	17.0 (15.2 -18.9)	670 (460- 780)	17.4 (14.3 -19.4)	490 (330- 650)

[a] Range of carbon-14 values given in parentheses.

for 1965–1973 is shown in table 2. Carbon-14 measurements in milk will continue with an annual analysis performed in April of each year.

It is interesting to note that carbon-14 concentrations in food have decreased more rapidly than the carbon-14 concentrations in milk. The Federal Radiation Council (*1*) predicted that the carbon-14 produced by atmospheric nuclear weapons tests would "be removed from the atmosphere by exchange with the ocean with a rate corresponding to a half-time of about 33 years." The data in table 2 indicate that it is being removed from food with a half-time rate of about 6 years.

REFERENCE

(*1*) FEDERAL RADIATION COUNCIL. Estimates and evaluation of fallout in the United States from nuclear weapons testing conducted through 1962, Report No. 4. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1963).

Other coverage in *Radiation Data and Reports:*

Period	Issue
July 1965–December 1968	November 1969
January 1969–June 1970	January 1971
July–December 1970	May 1971
January–June 1971	December 1971
July–December 1971	May 1972

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Radionuclides in Institutional Diet Samples, January–March 1973

Environmental Protection Agency and
Food and Drug Administration

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. Recognizing that the diet is a potentially significant contribution to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. The program is now administered by the Office of Radiation Programs, Environmental Protection Agency with the assistance of the Office of Food Sanitation, Food and Drug Administration, Department of Health, Education, and Welfare (*1*).

This program estimates the dietary intake of radionuclides in a selected population group, ranging from children to young adults of school age. At present 26 institutions—distributed geographically as shown in figure 1—are being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, but teenage boys consumed 20 percent more food per day (*1*, *2*). Extrapolating this information, estimates for teenage boys and/or girls can be calculated on the basis of the dietary intake of children.

The sampling procedure is generally the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week, (21 meals plus between-meal snacks) obtained by duplicating the food intake of a different individual daily. Drinking water—which is not included—is also sampled periodically. Each daily sample is kept frozen until the end of the collection period. It is then packed in dry ice and shipped by air to either the National Environmental Research Center, Las Vegas, Nev. or the Eastern Environmental Radiation Facility, Montgomery, Ala. A detailed description

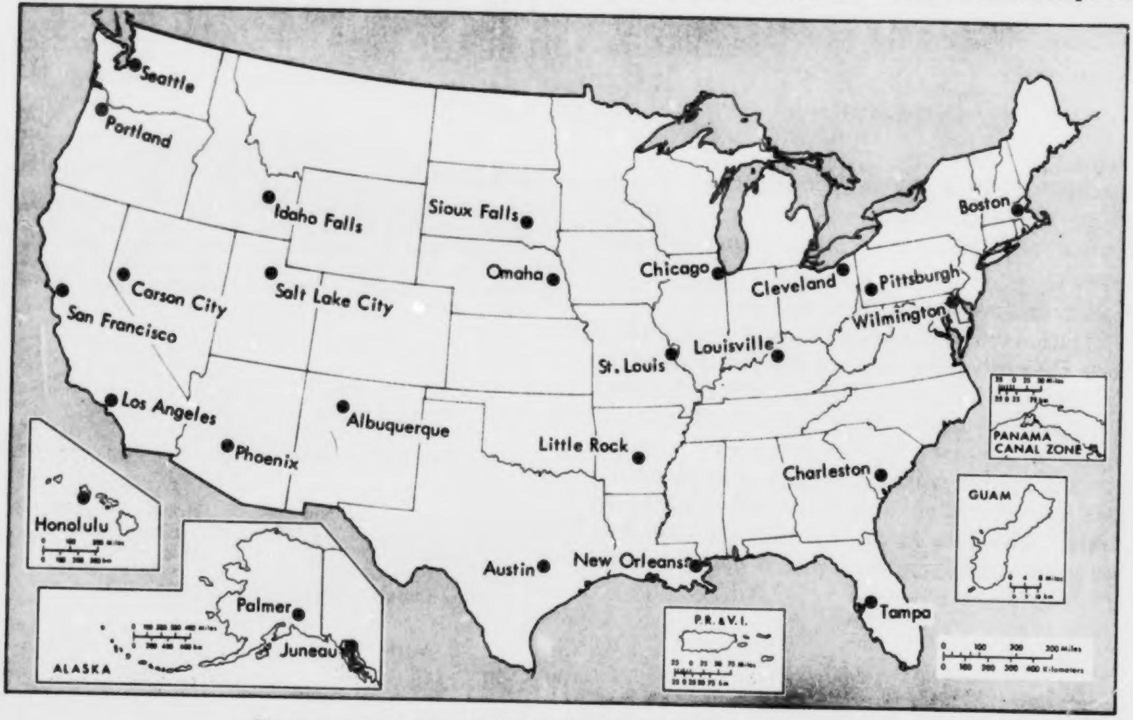
Seattle
Portland
Idaho Falls
Sioux Falls
Boston
Omaha
Chicago
Cleveland
Pittsburgh
Carson City
Salt Lake City
Wilmington
San Francisco
Louisville
St. Louis
Los Angeles
Albuquerque
PANAMA CANAL ZONE
Little Rock
Phoenix
Charleston
GUAM
Honolulu
Austin
New Orleans
Palmer
Tampa
P.R. & V.I.
Juneau
ALASKA
0 100 200 300 Miles
0 100 200 300 400 Kilometers

Figure 1. Institutional diet sampling locations as of March 1973

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Table 1. Concentration and intake of stable elements and radionuclides in institutional total diets of children January-March 1973

Location of institution	Month [a] (1973)	Total weight (kg/day)	Calcium		Potassium		Strontium-90		Cesium-137	
			(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska: Juneau	Jan	2.46	0.5	1.3	1.4	3.4	5	12	0	0
Palmer	Feb	1.76	.6	1.0	2.0	3.6	3	5	68	120
Ariz: Phoenix	Jan	1.25	.4	.6	1.5	1.9	6	8	0	0
Ark: Little Rock	Jan[b]	1.25	.5	.7	1.8	2.3	5	7	0	0
Calif: Los Angeles	NS									
San Francisco	Jan[b]	1.58	.5	.7	1.8	2.9	4	6	0	0
Del: Wilmington	Jan[b]	.93	.6	.6	1.1	1.0	4	4	0	0
7la: Tampa	Jan	1.83	.5	.9	1.2	2.2	4	7	14	26
Hawaii: Honolulu	Jan	2.14	.4	.9	1.6	3.5	6	12	0	0
Idaho: Idaho Falls	Jan[b]	1.29	.6	.8	1.6	2.1	0	0	0	0
Ill: Chicago	NS									
Ky: Louisville	Jan	2.18	1.0	2.3	1.5	3.3	6	13	0	0
La: New Orleans	Jan[b]	1.66	.5	.8	1.7	2.9	6	10	0	0
Mass: Boston	Jan	2.62	.6	1.6	1.3	3.4	5	12	0	0
Mo: St. Louis	Jan	.91	.5	.5	1.4	1.3	4	4	0	0
Nebr: Omaha	Jan[b]	1.85	.6	1.2	1.5	2.9	9	16	0	0
Nev: Carson City	Jan	1.32	.6	.8	1.7	2.3	0	0	0	0
N. Mex: Albuquerque	Jan[b]	1.84	.7	1.3	2.0	3.7	4	6	0	0
Ohio: Cleveland	Jan[b]	.94	.7	.6	1.7	1.6	6	6	17	16
Oreg: Portland	Jan[b]	2.24	.6	1.3	2.0	4.5	3	7	0	0
Pa: Pittsburgh	Jan	3.12	.4	1.2	1.2	3.6	4	12	0	0
S.C: Charleston	Jan	1.88	.8	1.6	1.4	2.7	5	10	00	0
S. Dak: Sioux Falls	Jan	1.16	.6	.7	1.7	2.0	6	7	0	0
Tex: Austin	Jan[b]	1.29	.6	.8	2.0	2.6	3	4	0	0
Utah: Salt Lake City	Jan[b]	2.04	.5	1.1	1.4	2.9	2	4	0	0
Wash: Seattle	Jan[b]	1.49	.4	.7	1.7	2.6	3	4	0	0
Institutional average		1.71	0.6	1.0	1.6	2.7	4	7	4	7

[a] Quarterly sample usually collected the first month of the quarter.
[b] Food samples were collected from two or more children who were not between the ages of 9 and 12.
Note: Iodine-131, barium-140, and strontium-89 were not detected at any station during this period.
NS, no sample.

of sampling and analytical procedures has already been presented in *Radiological Health Data and Reports.*

Results

Table 1 shows the analytical results for institutional diet samples collected from all stations during January–March 1973. The stable elements, calcium and potassium, are reported in g/kg of diet. Where applicable, radionuclide concentrations of these samples reported in pCi/kg of diet are corrected for radioactive decay to the midpoint of the sample collection period. Dietary intakes in g/day or pCi/day were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.71 kg/day compared to the network average of 1.84 kg/day observed from 1961 through 1972.

Strontium-90 dietary intake averaged 7 pCi/day during this period. Cesium-137 intake averaged 7 pCi/day. These results fall within Range I as defined by the former Federal Radiation Council (*4*). Strontium-89, barium-140, and iodine-131 concentrations were below detectable levels.

All concentrations less than or equal to the appropriate minimum detectable level have been reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the 2 standard deviation analytical error. Accordingly, the minimum detectable limits are strontium-89, 5 pCi/kg; strontium-90, 2 pCi/kg; iodine-131, 10 pCi/kg; barium-140 10 pCi/kg; and cesium-137, 10 pCi/kg.

REFERENCES

(*1*) ANDERSON, E. C., D. J. NELSON, JR. Surveillance for radiological contamination in foods. Amer J Public Health 52:1391–1400 (September 1962).

(*2*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1965. Radiol Health Data Rep 6:548–554 (Octobr 1965).

(*3*) PUBLIC HEALTH SERVICE, NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1968. Radiol Health Data Rep 9:557–560 (October 1968).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Recent coverage in *Radiation Data and Reports:*

Period	Issue
January–March 1972	June 1973
April–June 1972	July 1973
July–September 1972	August 1973
October–December 1972	September 1973

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
Colorado River Basin	1968	March 1972
Community Water Supply Study	1968	September 1972
Florida	1969	January 1972
Interstate Carrier Drinking Water	1971	May 1972
Kansas	January–December 1971	February 1973
Michigan	January–June 1970	November 1971
Minnesota	July 1970–June 1971	November 1972
New York	July–December 1971	August 1973
North Carolina	1968–1970	September 1972
Radiostrontium in Tap Water, *HASL*	July–December 1971	November 1972
Tritium Surveillance System	April–June 1973	October 1973
Washington	July 1970–June 1971	August 1973
Water Surveillance Programs, *NERC-LV*	April–May 1973	October 1973

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies, Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Water Surveillance Programs, June–July 1973

National Environmental Research Center-
Las Vegas
Environmental Protection Agency

The Water Surveillance Network,[1] operated by the National Environmental Research Center-Las Vegas (NERC-LV), consists of 61 sampling locations (figures 1 and 2) situated in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing programs conducted by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site.

In the event of a release of radioactivity from

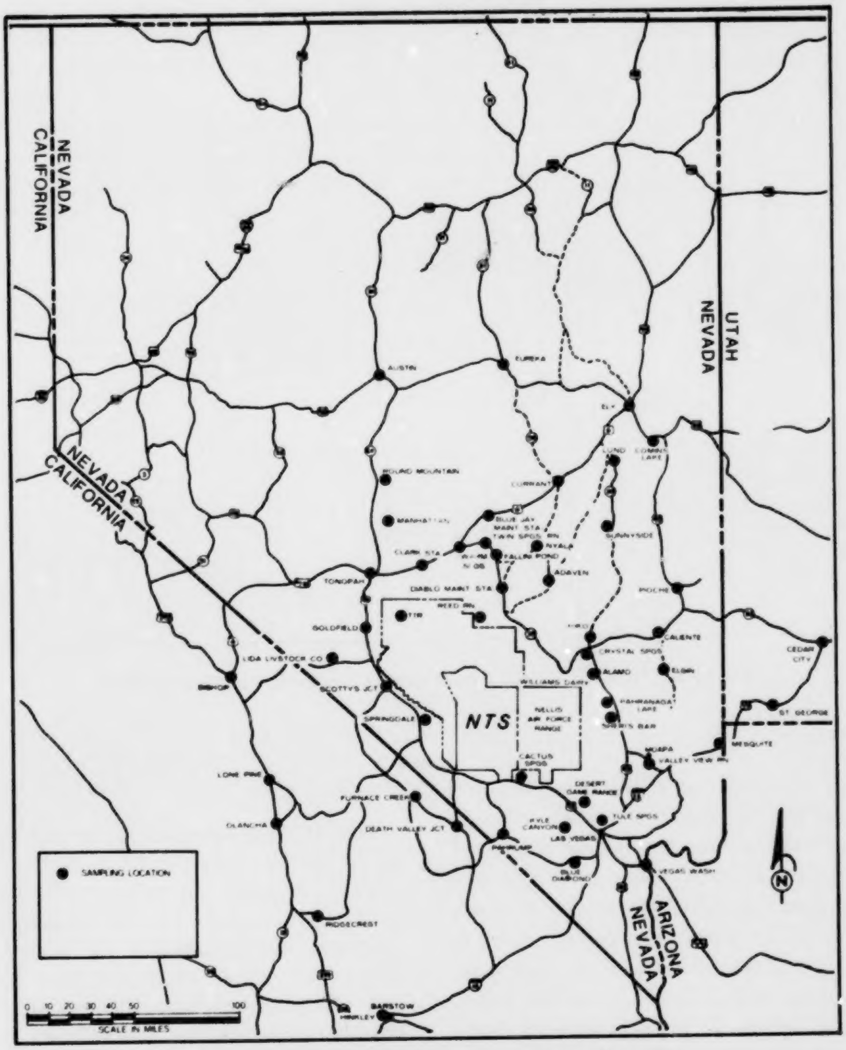
NEVADA
CALIFORNIA
UTAH
NEVADA
ARIZONA
NEVADA
AUSTIN
EUREKA
ELY
LUND
COMINS LAKE
ROUND MOUNTAIN
CURRANT
MANHATTAN
BLUE JAY MAINT STA
TWIN SPGS RN
NYALA
CLARK STA
WARM SPGS
FALLINI POND
ADAVEN
SUNNYSIDE
TONOPAH
DIABLO MAINT STA
PIOCHE
REED RN
TTR
GOLDFIELD
HIKO
CALIENTE
CRYSTAL SPGS
CEDAR CITY
LIDA LIVSTOCK CO
ALAMO
ELGIN
BISHOP
SCOTTYS JCT
WILLIAMS DAIRY
PAHRANAGAT LAKE
ST GEORGE
SPRINGDALE
NTS
NELLIS AIR FORCE RANGE
SHERIS BAR
MESQUITE
CACTUS SPGS
MOAPA
VALLEY VIEW RN
LONE PINE
FURNACE CREEK
DESERT GAME RANGE
TULE SPGS
KYLE CANYON
OLANCHA
DEATH VALLEY JCT
LAS VEGAS
PAHRUMP
BLUE DIAMOND
VEGAS WASH
SAMPLING LOCATION
RIDGECREST
BARSTOW
HINKLEY
0 10 20 30 40 50 100
SCALE IN MILES
N

Figure 1. NERC-LV Water Surveillance Network

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[1] This network is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. AEC, Las Vegas, Nev.

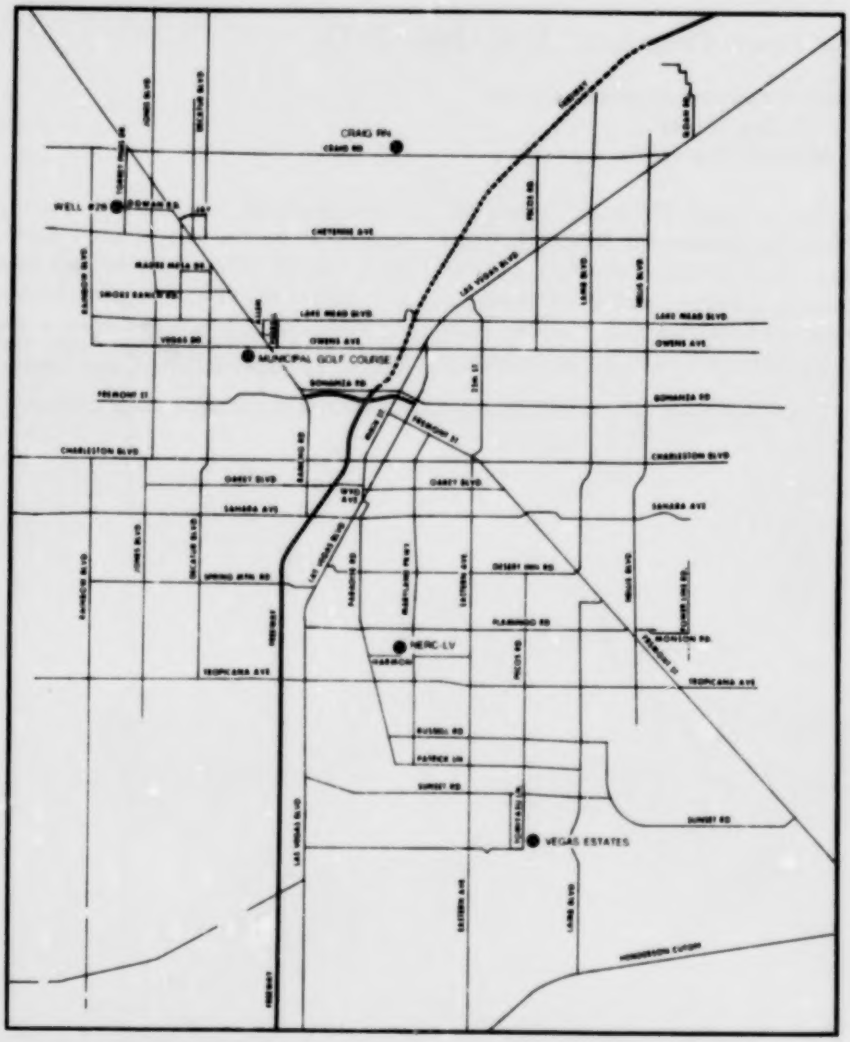
CRAIG RN
CRAIG RD
WELL #28
BONANZA RD
CHEYENNE AVE
LAKE MEAD BLVD
OWENS AVE
VEGAS DR
MUNICIPAL GOLF COURSE
FREMONT ST
CHARLESTON BLVD
SAHARA AVE
SPRING MTN RD
DESERT INN RD
FLAMINGO RD
NERC-LV
HARMON
TROPICANA AVE
RUSSELL RD
PATRICK LN
SUNSET RD
VEGAS ESTATES
LAS VEGAS BLVD
EASTERN AVE
LAMB BLVD
NELLIS BLVD
RAINBOW BLVD
JONES BLVD
DECATUR BLVD
PARADISE RD
MARYLAND PKWY
PECOS RD
FREEWAY
HENDERSON CUTOFF
MONSON RD
BOULDER HWY

Figure 2. NERC-LV Water Surveillance Network, Las Vegas Valley

the NTS, special sampling within the affected area is conducted to determine radionuclide concentrations and to take protective action, if required. Additional sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and routine analytical procedures was included with the water results reported in the July 1973 issue of *Radiation Data and Reports.*

Results

The routine analytical results of all water samples collected in June and July 1973 by the NERC-LV water surveillance network are listed in tables 1 and 2. No gamma-emitting fission products were identified by gamma spectrometry in any of the June and July 1973 samples. The analytical results for calendar year 1973 samples selected for special analyses will be reported at a later date.

Table 1. Water surveillance results, June 1973

Location	Date collected (June 1973)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
California:					
Bishop:					
Fish and Game Office	14	23	<1.4	<3.3	NA
Death Valley Junction:					
Lila's Cafe	14	23	<4.3	6.8±3.9	<240
Furnace Creek:					
Pond	14	21	<3.2	7.8±3.8	NA
Visitor Center	14	27	<2.0	7.5±3.8	NA
Hinkley:					
Bill Nelson Dairy	13	23	7.6±4.7	6.5±3.6	NA
Lone Pine:					
Forest Service Ranger Station	13	23	<1.5	<3.4	NA
Olancha:					
Haiwee Reservoir	13	21	4.3±2.8	<3.4	NA
Ridgecrest:					
City Hall	13	23	4.5±3.6	<3.4	NA
Nevada:					
Adaven:					
Canfield Ranch	12	22	3.5±2.6	<3.4	NA
Alamo:					
Pahranagat Lake	11	21	8.0±5.0	17 ±4.2	NA
Sheri's Bar	11	22	<2.2	<3.4	NA
Williams Dairy	11	23	4.5±3.8	12 ±4.0	NA
Ash Meadows:					
Ash Meadows Lodge	NS				
Pond	NS				
Austin:					
Nevada National Bank	NS				
Blue Diamond:					
Post Office	12	23	5.0±3.6	<3.6	<250
Blue Jay Highway:					
Maintenance Station	14	23	4.5±3.3	<3.4	NA
Cactus Springs:					
Mobil Service Station	11	27	<2.0	<3.3	<240
Caliente:					
Agricultural Extension Station	13	23	7.5±4.0	4.1±3.4	NA
Clark Station:					
Five Mile Ranch	14	27	<1.3	5.7±3.5	NA
Currant:					
Currant Ranch Cafe	19	27	6.0±4.0	3.7±3.4	NA
Diablo:					
Highway Maintenance Station	12	23	<2.2	5.7±3.6	NA
Reed Ranch	11	21	13 ±5.7	19 ±4.3	NA
Elgin:					
Water tower	13	23	5.1±4.0	5.6±3.6	NA
Ely:					
Chevron Service Station	18	24	4.4±2.9	<3.3	NA
Comins Lake	18	21	15 ±6.6	27 ±4.7	NA
Eureka:					
Highway Maintenance Station	1	24	4.7±3.3	6.8±3.5	NA
Goldfield:					
Chevron Service Station	13	23	<3.0	3.5±3.5	NA
Hiko:					
Crystal Springs	11	27	7.8±4.0	4.9±3.4	NA
Schofield Dairy	11	23	23 ±7.9	23 ±4.5	NA
Las Vegas:					
Craig Ranch Golf Course	11	23	4.8±3.0	<3.5	<250
Desert Game Range	11	24	4.0±2.8	<3.5	<250
Lab II NERC	11	24	<3.4	6.3±3.6	700±250
Lake Mead Vegas Wash	11	21	<3.4	<3.4	640±280
Las Vegas District Well 28	11	23	<2.1	<3.3	<250
Municipal Golf Course	11	23	<2.2	4.4±3.3	<250
Tule Springs	11	23	4.3±2.8	<3.5	<250
Tule Springs Pond	11	21	2.4±2.1	<3.5	NA
Vegas Estates	12	23	4.2±4.0	8.7±3.7	<250
Lida:					
Lida Livestock Company	10	27	4.4±3.2	<3.4	NA
Pond at storage tank	10	21	3.0±2.5	<3.3	NA
Lund:					
Gardner Grocery	19	23	2.9±2.8	<3.3	NA
Manhattan:					
Country store	14	23	20 ±7.1	<3.5	NA
Mesquite:					
Hughes Bros. Dairy	12	23	6.1±5.8	15 ±4.5	NA
Moapa:					
Pedersen Valley View Ranch	12	27	6.9±4.8	8.0±3.8	NA
Mt. Charleston:					
Kyle Canyon Fire Station	11	27	2.5±2.4	<3.3	<250
Nyala:					
Sharp's Ranch	12	23	<1.9	<3.4	NA
Pahrump:					
Texaco Service Station	13	23	<1.5	<3.4	NA
Pioche:					
County courthouse	12	24	2.8±2.4	3.4±3.3	NA

See footnotes at end of table.

Table 1. Water surveillance results, June 1973—continued

Location	Date collected (June 1973)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
Round Mountain:					
Mobil Service Station	14	27	2.5±2.1	<3.3	NA
Scotty's Junction:					
Chevron Service Station	10	23	4.5±4.1	12 ±4.0	<240
Springdale:					
Pond	13	21	<3.1	11 ±3.9	NA
Sunnyside:					
Adam McGill Reservoir	19	21	7.6±4.3	5.9±3.5	NA
Wildlife Management Headquarters	19	27	<2.4	3.6±3.4	NA
Tonopah:					
Jerry's Chevron Station	13	23	5.0±3.6	5.9±3.6	NA
Tonopah Test Range CP-1	13	23	<3.1	4.0±3.5	NA
Warm Springs:					
Fallini's Pond	12	21	19 ±9.0	49 ±6.0	NA
Service Station and Cafe	14	27	22 ±8.8	29 ±4.9	NA
Twin Springs Ranch	14	23	8.5±4.5	9.5±3.7	NA
Utah:					
Cedar City:					
M. D. Baldwin residence	13	24	<2.0	<3.3	NA
St. George:					
R. Cox Dairy	13	24	1.6±1.5	<3.3	NA

[a] 21—Pond, lake, reservoir, stock tank, stock pond.
22—Stream, river, creek.
23—Well.
24—Multiple supply-mixed water sample consisting of mixed or multiple sources of water, such as well or spring.
27—Spring.

[b] Two-sigma counting error provided when available.
NA, no analysis.
NS, no samples.

Table 2. Water surveillance results, July 1973

Location	Date collected (July 1973)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
California:					
Bishop:					
Fish and Game Office	19	23	<1.4	<3.5	NA
Death Valley Junction:					
Lila's Cafe	20	23	<3.9	8.0±4.0	<230
Furnace Creek:					
Pond	20	21	<3.2	7.7±3.8	NA
Visitor Center	20	27	<4.1	6.0±3.7	NA
Hinkley:					
Bill Nelson Dairy	17	23	9.0±5.8	<3.6	NA
Lone Pine:					
Forest Service Ranger Station	19	24	<1.7	<3.5	NA
Olancha:					
Haiwee Reservoir	18	21	<1.5	<3.5	NA
Ridgecrest:					
City Hall	18	23	<3.5	<3.5	NA
Nevada:					
Adaven:					
Canfield Ranch	11	22	<3.2	<3.5	NA
Alamo:					
Pahranagat Lake	17	21	12 ±6.6	20 ±4.5	NA
Sheri's Bar	17	23	<2.9	<3.5	NA
Williams Dairy	17	23	<4.2	9.2±3.9	NA
Austin:					
Nevada National Bank	NS	27			
Blue Diamond:					
Post Office	5	23	<3.2	<3.7	<240
Blue Jay Highway:					
Maintenance Station	10	23	<2.5	3.9±3.5	NA
Cactus Springs:					
Mobil Service Station	9	27	<2.0	<3.8	<230
Caliente:					
Agricultural Extension Station	18	23	<3.4	<3.5	NA
Clark Station:					
Five Mile Ranch	10	27	<2.8	7.8±3.8	NA
Currant:					
Currant Ranch Cafe	17	27	6.9±5.2	<3.6	NA

See footnotes at end of table.

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Table 2.—Water surveillance results, July 1973—continued

Location	Date collected July (1973)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
Nevada—continued					
Diablo:					
Highway Maintenance Station	9	23	<2.7	6.3±3.7	NA
Reed Ranch	9	21	18 ±6.0	7.0±3.7	NA
Elgin:					
Water tower	19	23	5.8±4.9	8.0±3.8	NA
Ely:					
Chevron Service Station	17	24	<2.4	<3.5	NA
Comins Lake	16	21	7.4±5.6	28 ±4.9	NA
Eureka:					
Highway Maintenance Station	2	24	<2.6	<3.6	NA
Goldfield:					
Chevron Service Station	9	24	7.6±5.1	8.3±3.7	NA
Hiko:					
Crystal Springs	17	27	8.4±4.5	3.7±3.5	NA
Schofield Dairy	17	23	26 ±8.6	28 ±4.8	NA
Las Vegas:					
Craig Ranch Golf Course	5	23	6.1±3.7	<3.6	<230
Desert Game Range	5	23	3.2±2.8	<3.6	<230
Lab II NERC	5	24	<3.7	6.3±3.9	880±250
Lake Mead Vegas Wash	5	21	<3.0	<3.7	900±250
Las Vegas Water District Well 28	6	23	2.7±2.6	<3.6	<230
Municipal Golf Course	6	23	3.3±2.8	<3.6	<230
Tule Springs	5	23	3.1±2.6	<3.6	<230
Tule Springs Pond	5	21	2.3±2.2	<3.6	NA
Vegas Estates	5	23	<4.2	7.1±3.9	<230
Lida:					
Lida Livestock Company	9	27	<3.0	<3.5	NA
Pond at storage tank	9	21	<2.2	<3.5	NA
Lund:					
Gardner Grocery	18	23	<2.5	<3.5	NA
Manhattan:					
Country store	10	23	9.9±5.6	<3.4	NA
Mesquite:					
Hughes Bros. Dairy	2	23	<5.9	19 ±5.0	NA
Moapa:					
Pedersen Valley View Ranch	2	27	<3.9	4.3±3.8	NA
Mt. Charleston:					
Kyle Canyon Fire Station	5	27	<1.7	<3.6	<230
Nyala:					
Sharp's Ranch	10	23	<2.8	<3.5	NA
Pahrump:					
Texaco Service Station	10	23	<2.8	<3.3	NA
Pioche:					
County courthouse	18	24	<2.1	<3.5	NA
Round Mountain:					
Mobil Service Station	10	27	<2.3	<3.5	NA
Scotty's Junction:					
Chevron Service Station	9	23	<5.7	4.8±3.7	<220
Springdale:					
Pond	10	21	<4.0	6.8±3.7	NA
Sunnyside:					
Adam McGill Reservoir	18	21	<3.1	4.9±3.6	NA
Wildlife Management Headquarters	18	27	<2.5	<3.5	NA
Tonopah:					
Jerry's Chevron Station	11	23	<3.3	<3.5	NA
Tonopah Test Range CP-1	11	2[illegible]	<3.0	4.2±3.6	NA
Warm Springs:					
Fallini's Pond	11	21	[illegible]3 ±8.8	40 ±5.7	NA
Service Station and Cafe	10	27	18 ±9.0	20 ±4.6	NA
Twin Springs Ranch	10	23	4.5±4.2	7.3±3.7	NA
Utah:					
Cedar City:					
M. D. Baldwin residence	3	24	<1.6	<3.6	NA
St. George:					
R. Cox Dairy	3	24	2.4±1.9	<3.6	NA

[a] 21—Pond, lake, reservoir, stock tank, stock pond.
22—Stream, river, creek.
23—Well.
24—Multiple supply mixed (a water sample consisting of mixed or multiple sources of water such as well and spring).
27—Spring.

[b] Two-sigma counting error provided when available.
NA, not analyzed.
NS, no sample.

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Radioactivity in California Waters,[1] January–December 1971 and January–December 1972

Radiologic Health Section, State of California Department of Health

The Radiologic Health Section of the California State Department of Health has maintained a program of domestic water sampling for radioanalyses since 1960. The source of radionuclides in water supplies includes the natural radioactivity, the contribution from fallout, and in a few instances, the activity added by sewage discharges and industrial effluents. The California Domestic Water Network stations are shown in figure 1.

The monitoring program consists primarily of monthly sampling of domestic water at the point of consumption (at the tap) and analyzing them for gross beta radioactivity. Fourteen of the 20 locations are surface water supplies, three are wells, two are Ranney wells, and one is a spring.

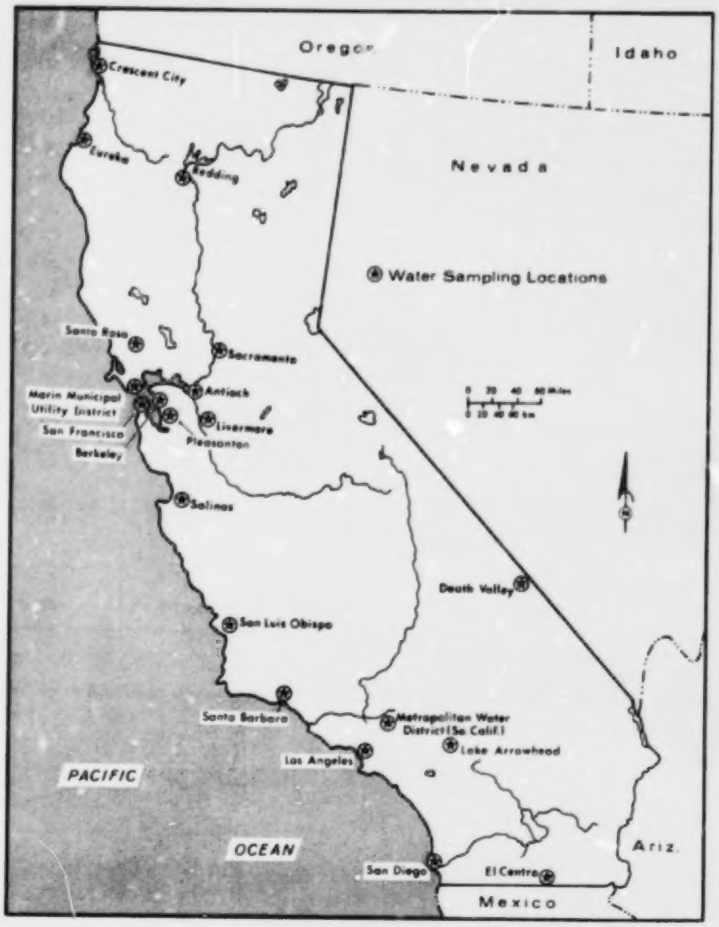
Oregon
Idaho
Nevada
Crescent City
Eureka
Redding
Water Sampling Locations
Santa Rosa
Sacramento
Marin Municipal Utility District
San Francisco
Berkeley
Antioch
Livermore
Pleasanton
Salinas
Death Valley
San Luis Obispo
Santa Barbara
Metropolitan Water District (So Calif.)
Lake Arrowhead
Los Angeles
PACIFIC
OCEAN
San Diego
El Centro
Mexico
Ariz.

Figure 1. California domestic water network

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[1] Data from State of California, Department of Health, Radiologic Health Section, 744 P Street, Sacramento, Calif. 95814.

The purpose of this program is to determine the radioactivity of the water. Water processed in any manner that might remove radioactivity therefrom is defined herein as treated water. Thus, a water treatment plant that employs coagulation, sedimentation, filtration, or similar processes is considered for our purposes to produce treated water. Chlorination is not considered as treatment from a radiological viewpoint. Well waters, including springs and Ranney wells, are usually pumped directly to the distribution system with nothing more than chlorination, and are considered as raw water. It is not implied by the use of the words "raw" and "treated" that the waters are not potable or bacterially safe.

Under the present sampling schedule, monthly 500 milliliter samples are collected by the purveyor of 20 water supplies and sent to the Sanitation and Radiation Laboratory at Berkeley. In addition, the purveyor collects a yearly composite which is analyzed for specific radionuclides.

Analytical procedures

Radioanalyses of the water samples are made by the Sanitation and Radiation Laboratory of the State Department of Health. Measurements of gross beta radioactivity on the monthly samples are made by evaporating the samples to dryness and analyzing the solids for gross beta radioactivity in a windowless, gas-flow proportional counter. The yearly composites are collected throughout the year to make a 5-gallon sample. The entire sample is reduced to dryness. A gamma scan is made on the dry solids with a 10- by 10-cm (4- by 4-inch) sodium iodide (thallium activated) detector. Eight radionuclides are determined. Radiochemical analyses are performed to obtain radium and strontium-90 values. Analytical procedures are those recommended by the Environmental Protection Agency (*1*).

Sewage samples

Sewage samples are collected from 20 treatment plants throughout the State (figure 2). Many of the cities used as sampling locations in this program are the same as those in the domestic water sampling program. Results of analyses of sewage effluent and sludge samples provide a means of assuring that industrial radioactive wastes discharged into sewage systems do not become excessive. The surveillance of sewage assumes greater importance as isotope licenses become more numerous and as the quantity of radioactive material per user in-

Table 1. Gross beta radioactivity in California domestic waters, January-December 1971

Sampling station	Type [a]	Concentration (pCi/liter)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Antioch	Treated	3	13	3	0	NS	NS	8	0	4	25	NS	1
Berkeley	Treated	6	6	1	9	1	5	3	6	4	2	0	2
Crescent City	Ranney well	NS	NS	NS	NS	1	4	4	2	NS	12	5	0
Death Valley	Spring	NS	NS	NS	NS	16	322	3	5	NS	28	26	NS
El Centro	Treated	23	NS	14	22	22	0	14	16	20	0	31	NS
Eureka	Well	2	NS	12	6	2	6	7	7	10	8	0	6
Lake Arrowhead	Raw	NS	1	NS	NS	5	11	3	11	NS	23	18	NS
Livermore	Well	0	0	0	0	4	NS	0	11	8	11	0	0
Los Angeles	Raw	10	6	0	17	20	18	NS	3	101	0	3	10
Marin Municipal Water District	Treated	3	0	10	1	6	4	2	5	13	3	9	3
Metropolitan Water District of Southern Calif	Treated	20	26	11	44	32	62	72	55	11	34	3	25
Pleasanton	Well	0	12	0	11	0	14	34	5	0	9	6	0
Redding	Treated	NS	NS	NS	NS	3	4	11	13	22	3	5	1
Sacramento	Treated	10	7	5	1	0	2	13	NS	4	NS	NS	0
San Diego	Treated	10	20	17	66	4	19	14	9	55	4	6	3
San Francisco	Raw	2	9	4	0	6	7	6	15	41	0	6	1
San Luis Obispo	Treated	NS	NS	NS	NS	14	10	0	NS	NS	11	16	10
Santa Barbara	Treated	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	15
Santa Rosa	Ranney well	29	10	43	1	0	2	1	8	2	1	1	0
Salinas	Well	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[a] Treated water means complete treatment, (note: chlorination is not considered as treatment); the use of words raw and treated does not imply the waters are not potable or not bacterially safe. The word "treated" implies that the water has been processed and has possibly changed the radioactive content of the water.

NS, no sample.

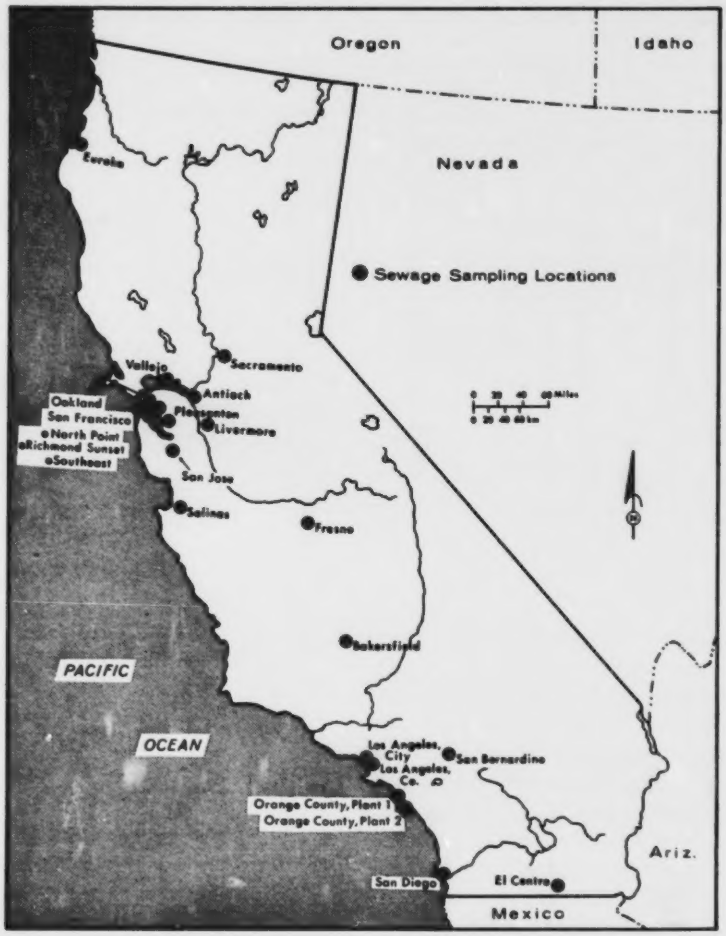
Oregon
Idaho
Nevada
● Sewage Sampling Locations
Eureka
Vallejo
Sacramento
Antioch
Oakland
San Francisco
●North Point
●Richmond Sunset
●Southeast
Pleasanton
Livermore
San Jose
Salinas
Fresno
Bakersfield
0 20 40 60 Miles
0 20 40 60 km
N
PACIFIC
OCEAN
Los Angeles, City
Los Angeles, Co.
San Bernardino
Orange County, Plant 1
Orange County, Plant 2
San Diego
El Centro
Ariz.
Mexico

Figure 2. California sewage network

creases. Analysis procedures for sewage effluents are the same as the method used for domestic water except that alpha analyses are also included. The sludge samples are dried and ashed. The ashed residue is counted for alpha and beta radioactivities in a gas-flow proportional counter.

Results and discussion

Tables 1 and 2 show the monthly average beta radioactivity in the suspended-plus-dissolved solids in surface and well water supplies in California for the calendar years 1971 and 1972. Those water supplies listed in table 1 that have a potential for becoming contaminated with radioactive material either from sewage discharges or industrial effluents are: Antioch, sewage; El Centro, industrial; Los Angelos (20 percent), industrial; Metropolitan Water District of Southern California, industrial; and San Diego, industrial. The source of water for the last four (all except Antioch) is the Colorado River.

Tables 3 and 4 present the isotopic analyses for annual composites of a number of the domestic water samples during 1971 and 1972. Essentially all the radionuclides originating from fallout were below detectable limits, except for strontium-90, which for all locations

Table 5. Gross radioactivity in California sewage samples, 1971

Sewage treatment plant	Effluent (pCi/liter)		Sludge (pCi/g dry weight)	
	Alpha	Beta	Alpha	Beta
Antioch	2	14	6	14
Bakersfield	2	22	20	13
El Centro	10	16	24	30
Eureka	1	22	3	23
Fresno	1	32	16	27
Livermore	2	11	8	46
Los Angeles City	8	17	12	46
Los Angeles County	10	36	6	18
Oakland	4	29	6	17
Orange County No. 1	8	33	14	148
Orange County No. 2	17	34	11	35
Pleasanton	6	41	109	234
Sacramento	2	16	12	22
Salinas	9	38	14	25
San Bernardino	NS	NS	NS	NS
San Diego	8	41	16	28
San Francisco:				
North Point	8	28	NS	NS
Richmond-Sunset	1	22	6	30
Southeast	8	51	8	37
San Jose	6	24	5	44
Vallejo	2	28	4	14

Table 6. Gross radioactivity in California sewage samples, 1972

Sewage treatment plant	Effluent (pCi/liter)		Sludge (pCi/g dry weight)	
	Alpha	Beta	Alpha	Beta
Antioch	3	6	4	6
Bakersfield	1	10	15	17
El Centro	7	8	22	19
Eureka	2	6	1	6
Fresno	2	23	13	14
Livermore	0	10	8	23
Los Angeles City	7	13	10	27
Los Angeles County	4	30	6	8
Oakland	1	9	6	10
Orange County No. 1	2	23	14	17
Orange County No. 2	3	18	9	6
Pleasanton	4	21	51	105
Sacramento	2	4	12	13
Salinas	9	12	12	11
San Bernardino	3	6	11	8
San Diego	5	35	13	19
San Francisco:				
North Point	3	23	NS	NS
Richmond-Sunset	0	8	4	12
Southeast	4	26	3	10
San Jose	1	2	6	5
Vallejo	0	9	7	1

was substantially below recommended ingestion limits for drinking water.

Tables 5 and 6 list the 1971 and 1972 yearly averages for alpha and beta radioactivity for sewage effluents and digested sludges. None of the plant effluents analyzed exceeded the maximum permissible concentration of alpha and beta emitting radionuclides that, in accordance with California's radiation control regulations, may be discharged into the uncontrolled environment (30 and 100 pCi/liter, respectively). One location (Pleasanton) indicated values for radioactivity in sludge samples which were consistently higher than desirable. Industries that are likely to be the principal sources of radionuclides contributed to the waste water treatment system have been advised of the Health Department's concern over the situation. A gradual reduction of radioactivity in the sludge has been apparent over the past few years, indicating that efforts toward compliance are being exercised by the waste dischargers involved.

Tables 7 and 8 show a comparison of domestic water and sewage effluent. One would expect the sewage and domestic water of a community to have essentially the same radioactivity. Where these values are not the same, the difference may be used to approximate the amount

Table 7. Comparison of gross beta radioactivity in California domestic water and sewage, 1971

Sampling station	Concentration (pCi/liter)			Ratio of sewage to water
	Water	Sewage	Difference	
Antioch	6	14	8	2.3
Berkeley-Oakland	4	29	25	7.2
El Centro	16	16	0	1.0
Eureka	6	22	16	3.7
Livermore	3	11	8	3.7
Los Angeles City	17	17	0	1.0
Pleasanton	8	41	33	5.1
Sacramento	5	16	11	3.2
San Diego	19	41	22	2.2
San Francisco, North Point	8	28	20	3.5
San Francisco, Richmond-Sunset	8	22	14	2.8
San Francisco, Southeast	8	51	43	6.4

Table 8. Comparison of gross beta radioactivity in California domestic water and sewage, 1972

Sampling station	Concentration (pCi/liter)			Ratio of sewage to water
	Water	Sewage	Difference	
Antioch	4	6	2	1.5
Berkeley-Oakland	2	9	7	4.5
El Centro	8	8	0	1.0
Eureka	6	6	0	1.0
Livermore	3	10	7	3.3
Los Angeles City	11	13	2	1.2
Pleasanton	10	21	11	2.1
Sacramento	4	4	0	1.0
San Diego	27	35	8	1.3
San Francisco, North Point	5	23	18	4.8
San Francisco, Richmond-Sunset	5	8	3	1.6
San Francisco, Southeast	5	26	21	5.2

of radioactive material entering the sewer system. Both the differences and ratio of beta concentration are shown. By evaluating both the sewage-water ratio and the difference, one can readily determine where vigilance of waste disposal practices into sewers is necessary.

REFERENCE

(*1*) DIVISION OF RADIOLOGICAL HEALTH. Radionuclide analysis of environmental samples, a laboratory manual of methodology, Technical Report R59-6. Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio 45226 (Revised February 1966).

Recent coverage in *Radiation Data and Reports:*

Period	Issue
January-December 1970	June 1972

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SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Pan American Health Organization, and the California air sampling program.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiation Data and Reports.*

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	1971	August 1973
Mexican air monitoring network	September–December 1972	June 1973
Plutonium in airborne particulates	October–December 1972	June 1973
Surface air sampling program, 80th Meridian Network, *HASL*	January–December 1971	September 1973

1. Radiation Alert Network
July 1973

Eastern Environmental Radiation Facility
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 68 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples 5 hours after collection, when most of the radon daughter products have decayed, and 29 hours after collection, when most of the thoron daughter products have decayed. The airborne particulate samples and precipitation samples are sent to the Eastern Environmental Radiation Facility for further analysis. All results are reported to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily measurements is available upon request from the Eastern Environmental Radiation Facility, P.O. Box 3009, Montgomery, Ala. 36109. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate and laboratory techniques during July 1973.

The Office of Radiation Programs is in the process of modifying the air program to make it more responsive to potential sources of environmental radioactivity. These changes will be reflected in future articles.

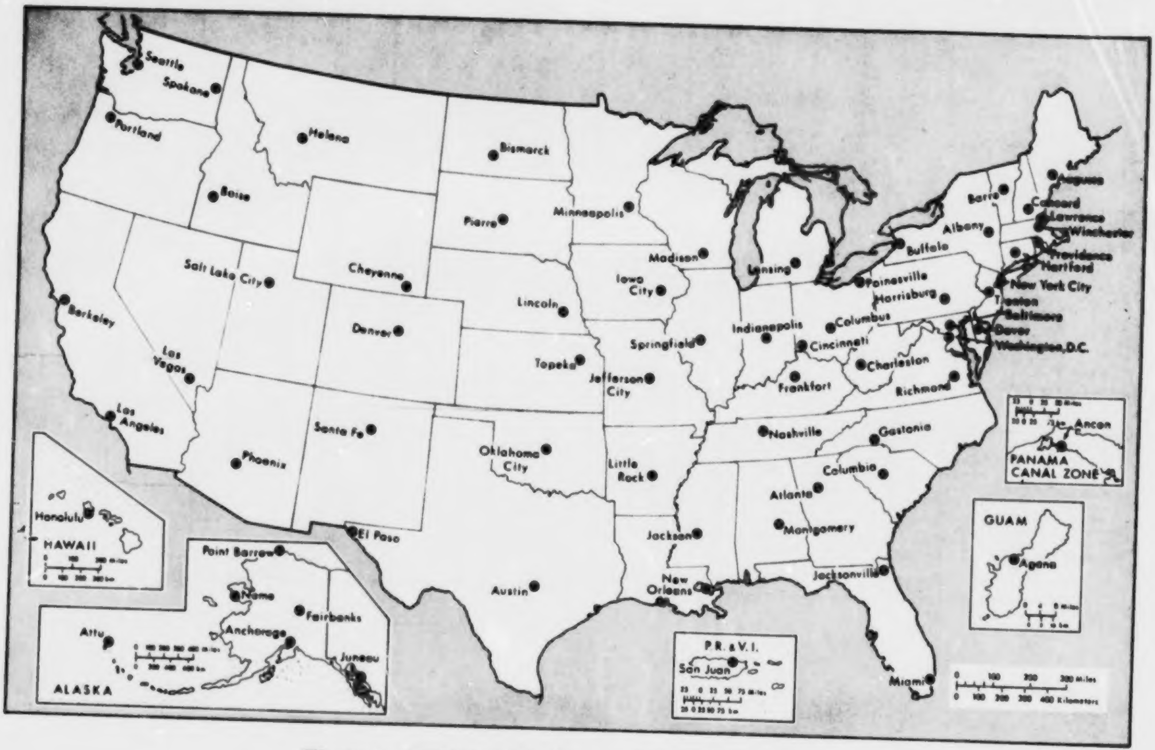
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Minneapolis
Pierre
Madison
Lansing
Salt Lake City
Cheyenne
Iowa City
Lincoln
Berkeley
Denver
Springfield
Indianapolis
Columbus
Cincinnati
Charleston
Topeka
Jefferson City
Frankfort
Richmond
Las Vegas
Los Angeles
Santa Fe
Oklahoma City
Nashville
Gastonia
Little Rock
Columbia
Atlanta
Phoenix
Montgomery
Jackson
Jacksonville
El Paso
Austin
New Orleans
Miami
Augusta
Barre
Concord
Lawrence
Winchester
Albany
Buffalo
Providence
Hartford
Painesville
Harrisburg
New York City
Trenton
Baltimore
Dover
Washington, D.C.
Honolulu
HAWAII
Point Barrow
Nome
Fairbanks
Anchorage
Attu
Juneau
ALASKA
P.R. & V.I.
San Juan
Ancon
PANAMA CANAL ZONE
GUAM
Agana
0 100 200 300 Miles
0 100 200 300 400 Kilometers

Figure 1. **Radiation Alert Network sampling stations**

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Table 1. Gross beta radioactivity in surface air and precipitation, July 1973

Station location	Number of samples	Gross beta radioactivity (pCi/m³)						Precipitation		
		5-hour field estimate			Laboratory measurement			Laboratory estimate of deposition		
		Maximum	Minimum	Average [a]	Maximum	Minimum	Average [a]	Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala: Montgomery	23	2	0	1	0.10	0.01	0.03	3	98	19.6
Alaska: Anchorage	0									
Attu Island	0									
Fairbanks	6	1	0	0	<.01	<.01	<.01	0		
Juneau	0									
Nome	0									
Point Barrow	0									
Ariz: Phoenix	5	3	1	2	.07	.02	.05	0		
Ark: Little Rock	6	2	0	1	.06	.02	.03	0		
Calif: Berkeley	13	1	0	0	.14	<.01	.02	0		
Los Angeles	16	2	0	1	.02	.01	.02	0		
C.Z: Ancon	16	0	0	0	.05	.01	.02	0		
Colo: Denver	19	4	1	3	.12	.03	.06	1	7	<.1
Conn: Hartford	16	1	0	1	.05	<.01	.02	5	81	.8
Del: Dover	17	1	0	0	.10	.02	.04	0		
D.C: Washington	0									
Fla: Jacksonville	15	1	0	0	.06	.02	.03	5	142	1.1
Miami	6	0	0	0	.03	<.01	.01	4	90	.1
Ga: Atlanta	13				.09	.02	.05	0		
Guam: Agana	0									
Hawaii: Honolulu	16	1	0	0	.07	<.01	.02	3	29	<.1
Idaho: Boise	14	2	1	1	.06	.02	.03	0		
Ill: Springfield	3	2	0	1	.03	<.01	.01	0		
Ind: Indianapolis	16	2	0	1	.05	.02	.03	0		
Iowa: Iowa City	9	3	1	2	.05	.02	.03	1	21	<.1
Kans: Topeka	14	6	0	2	.10	.01	.05	7	139	5.0
Ky: Frankfort	12	5	0	2	.14	<.01	.04	0		
La: New Orleans	13	1	0	0	.08	.02	.03	3	33	3.0
Maine: Augusta	15	1	0	0	.04	<.01	.02	0		
Md: Baltimore	9	2	0	1	.07	.02	.03	3	30	<.1
Mass: Lawrence	13	1	0	1	.09	.01	.03	2	80	<.1
Winchester	12	2	0	1	.07	.02	.03	5	42	<.1
Mich: Lansing	11	1	0	1	.03	.01	.02	6	37	3.8
Minn: Minneapolis	13	3	0	1	.12	.02	.05	4	42	5.0
Miss: Jackson	2	2	1	1	.05	.04	.04	0		
Mo: Jefferson City	15	3	0	2	.08	.02	.04	4	76	<.1
Mont: Helena	14	3	0	1	.08	.01	.03	1	4	<.1
Nebr: Lincoln	13	6	1	4	.30	.01	.08	1	58	.1
Nev: Las Vegas	20	2	0	1	.15	.01	.07	0		
N.H: Concord	0									
N.J: Trenton	16	2	0	1	.07	.02	.03	7	71	3.0
N. Mex: Santa Fe	10	2	0	1	.11	.01	.04	0		
N.Y: Albany	7	1	0	1	.07	.01	.03	0		
Buffalo	19	1	0	1	.06	.01	.03	0		
New York City	0									
N.C: Gastonia	8	5	1	3	.50	.03	.21	2	43	12.8
N. Dak: Bismarck	16	4	0	2	.09	<.01	<.03	1	1	<.1
Ohio: Cincinnati	0									
Columbus	7	2	0	1	.05	.03	.03	0		
Painesville	15	2	0	1	.04	.01	.03	2	34	.4
Okla: Oklahoma City	6	3	0	2	.05	<.01	.02	0		
Oreg: Portland	21	1	0	0	.03	<.01	.01	1	1	<.1
Pa: Harrisburg	13	3	0	1	.06	.01	.03	0		
P.R: San Juan	13				.03	<.01	.02			
R.I: Providence	10	1	0	0	.08	<.01	.03	0		
S.C: Columbia	11	3	0	1	.20	.02	.10	0		
S. Dak: Pierre	5	12	1	7	.40	.02	.20	0		
Tenn: Nashville	11	2	0	1	.11	<.01	.05	4	53	1.8
Tex: Austin	7	4	0	2	.03	<.01	.02	0		
El Paso	10	2	0	1	.12	<.01	.06	0		
Utah: Salt Lake City	19	2	1	1	.18	.02	.06	2	20	<.1
Vt: Barre	10	3	0	1				0		
Va: Richmond	13	2	0	0	.06	.02	.03	2	43	2.0
Wash: Seattle	13	1	0	0	.06	<.01	.02	0		
Spokane	8	1	0	1	.19	.02	.05	0		
W. Va: Charleston	8	3	1	1	.06	.02	.03	2	9	.5
Wisc: Madison	14	3	0	1	.05	.02	.03	2	33	.5
Wyo: Cheyenne	12	5	1	3	.16	.03	.08	0		
Network summary	697	12	0	1	0.50	<0.01	0.04	83	49	1.9

[a] The monthly average is calculated by weighting the measurements of individual air samples with length of sampling period.

2. Air Surveillance Network, July 1973

National Environmental Research Center-Las Vegas[1]
Environmental Protection Agency

The Air Surveillance Network[2] (ASN), operated by the National Environmental Research Center-Las Vegas (NERC-LV), consists of 49 active and 73 standby sampling stations located in 21 western States (figures 2 and 3). The network is operated in support of nuclear testing conducted by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), and at any other designated testing sites.

The stations are operated by State health department personnel and by private individuals on a contract basis. All active stations are operated continuously with filters being exchanged over periods generally ranging from 24 to 72 hours. All samples are mailed to the NERC-LV unless special retrieval is arranged at selected locations in response to known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

Results

Table 2 presents the average gross beta concentrations in air for each of the network stations. The minimum reporting concentration for gross beta activity is 0.1 pCi/m^3. For reporting purposes, concentrations less than 1.0 pCi/m^3 are reported to 1 significant figure, and those equal to or greater than 1.0 pCi/m^3 are reported to 2 significant figures. For averaging purposes, individual concentration values less than the minimum detectable concentration ($\sim$0.06 pCi/m^3 for a 350-m^3 sample) are set equal to the minimum detectable concentration (MDC). Reporting and rounding-off concentrations are indicated as follows:

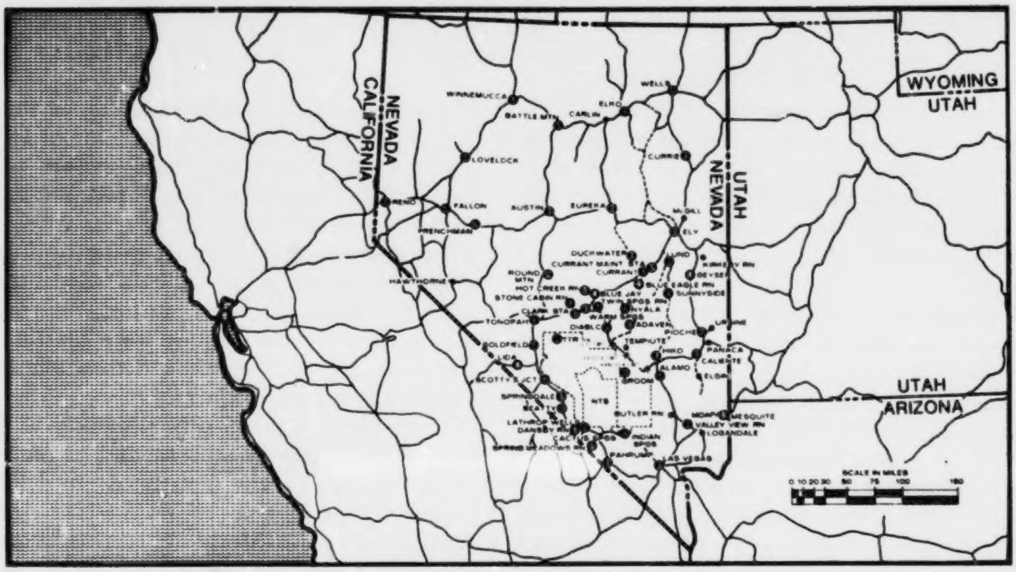
WYOMING
UTAH
NEVADA
CALIFORNIA
UTAH
NEVADA
UTAH
ARIZONA
WINNEMUCCA
BATTLE MTN
CARLIN
ELKO
WELLS
CURRIE
LOVELOCK
RENO
FALLON
FRENCHMAN
AUSTIN
EUREKA
McGILL
ELY
DUCKWATER
CURRANT MAINT STA
CURRANT
LUND
KIMBERLY RN
GEYSER
ROUND MTN
HAWTHORNE
HOT CREEK RN
BLUE JAY
BLUE EAGLE RN
SUNNYSIDE
STONE CABIN RN
TWIN SPGS RN
NYALA
CLARK STA
WARM SPGS
TONOPAH
DIABLO
ADAVEN
PIOCHE
URSINE
TTR
TEMPIUTE
GOLDFIELD
HIKO
PANACA
CALIENTE
LIDA
ALAMO
ELGIN
SCOTTY'S JCT
GROOM
SPRINGDALE
NTS
BEATTY
BUTLER RN
MOAPA
MESQUITE
LATHROP WELLS
VALLEY VIEW RN
DANSBY RN
LOGANDALE
CACTUS SPGS
INDIAN SPGS
SPRING MEADOWS RN
PAHRUMP
LAS VEGAS
SCALE IN MILES
0 10 20 30 50 75 100 150

Figure 2. NERC-LV Air Surveillance Network stations in Nevada

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[1] Formerly the Western Environmental Research Laboratory.

[2] The ASN is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

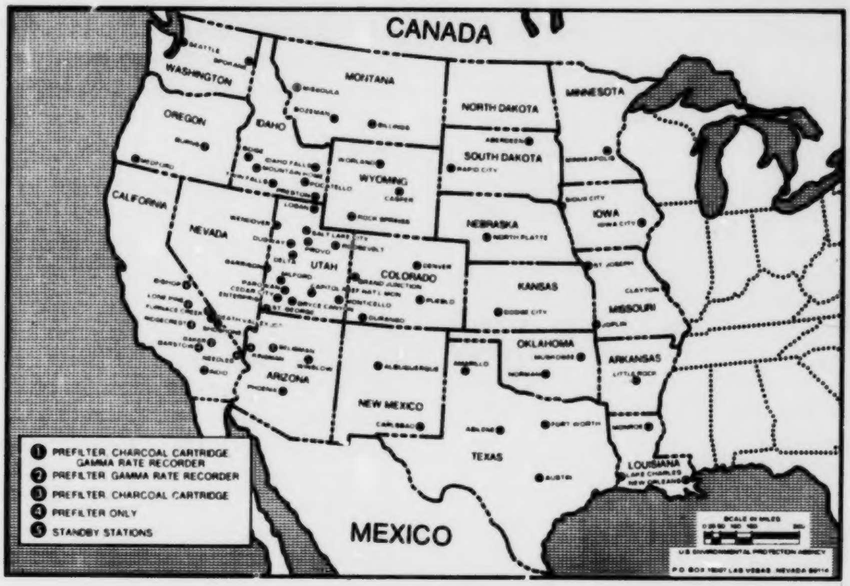
CANADA
WASHINGTON
OREGON
IDAHO
MONTANA
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
WYOMING
CALIFORNIA
NEVADA
UTAH
COLORADO
NEBRASKA
IOWA
KANSAS
MISSOURI
OKLAHOMA
ARKANSAS
ARIZONA
NEW MEXICO
TEXAS
LOUISIANA
MEXICO
1 PREFILTER CHARCOAL CARTRIDGE GAMMA RATE RECORDER
2 PREFILTER GAMMA RATE RECORDER
3 PREFILTER CHARCOAL CARTRIDGE
4 PREFILTER ONLY
5 STANDBY STATIONS
SCALE IN MILES
U.S. ENVIRONMENTAL PROTECTION AGENCY

Figure 3. NERC-LV Air Surveillance Network stations outside Nevada

Concentration (pCi/m^3)	Reported value of concentration above MDC (pCi/m^3)	Reported value of concentration below MDC (pCi/m^3)
<0.05	< 0.1	< 0.1
≧ .05 <0.15	.1	< .1
≧ .15	As calculated and rounded	< calculated MDC

As shown by a comparison of table 2 with gross beta concentrations reported earlier, the July gross beta concentrations at most locations were higher than for previous months, the highest concentration being 4.5 pCi/m^3 at Monticello, Utah. This sample was collected on July 11.

From gamma spectrometry results, ruthenium-103 was identified in one sample collected in Idaho Falls, Idaho, on July 11 and zirconium-95, cerium-141, and ruthenium-103 were identified in one sample collected in Las Vegas, Nev. on July 23. All concentrations were less than the minimum reporting concentration of 0.1 pCi/m^3. In addition, a special study was made of composited air filters representing 120,000 m^3 of sampled air. Gamma spectroscopy analysis of the composited filters indicated the presence of trace amounts of zirconium-95, cerium-141, ruthenium-103, and barium-lanthanum-140. The concentrations of these nuclides were too low for definite quantification. Since no gamma-emitting radionuclides had been identified in air samples for several months prior to July and slight increases in gross beta concentrations were observed at most stations during the month, these radionuclides were attributed to the June 26, 1973 nuclear detonation by the People's Republic of China.

Complete copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA Regional Offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC-LV upon written request.

Table 2. Summary of gross beta radioactivity concentrations in air, July 1973

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average
Ariz:	Kingman	31	1.8	0.1	0.3
	Phoenix	14	.4	<.1	.2
	Seligman	16	.4	<.1	.2
	Winslow	16	.5	<.1	.2
Ark:	Little Rock	7	.1	<.1	.1
Calif:	Baker	22	.2	<.1	.1
	Barstow	30	.3	<.1	.1
	Bishop	31	.4	<.1	.2
	Death Valley Junction	30	.6	<.1	.2
	Furnace Creek	31	.5	<.1	.2
	Lone Pine	28	.6	<.1	.2
	Needles	14	.7	<.1	.2
	Ridgecrest	31	.2	<.1	.1
	Shoshone	31	.5	<.1	.2
Colo:	Denver	17	.6	<.1	.2
	Durango	7	1.1	.1	.5
Idaho:	Boise	11	.2	<.1	.1
	Idaho Falls	11	.6	<.1	.2
	Preston	16	2.7	<.1	.4
	Twin Falls	6	<.1	<.1	.1
Iowa:	Iowa City	5	<.1	<.1	.1
	Sioux City	11	.7	<.1	.2
Kans:	Dodge City	9	.7	<.1	.2
La:	Lake Charles	10	<.1	<.1	.1
	Monroe	4	<.1	<.1	.1
	New Orleans	13	<.1	<.1	.1
Minn:	Minneapolis	8	.2	<.1	.1
Mo:	Clayton	10	.1	<.1	.1
	Joplin	16	.7	<.1	.1
Nebr:	North Platte	15	1.0	<.1	.3
Nev:	Alamo	31	.6	<.1	.2
	Austin	14	.2	<.1	.1
	Battle Mountain	15	.9	<.1	.3
	Beatty	31	.4	<.1	.2
	Blue Eagle Ranch (Currant)	31	1.0	<.1	.2
	Blue Jay	31	.4	<.1	.1
	Caliente	31	.5	<.1	.2
	Currant Ranch	31	.6	<.1	.2
	Diablo	31	.8	<.1	.2
	Duckwater	27	.8	<.1	.2
	Elko	16	.5	<.1	.2
	Ely	31	.3	<.1	.1
	Eureka	31	.6	<.1	.2
	Fallini's Twin Springs Ranch	31	.7	<.1	.2
	Fallon	15	.3	<.1	.2
	Frenchman Station	18	1.0	<.1	.2
	Geyser Maintenance Station	2	<.1	<.1	.1
	Goldfield	31	.5	<.1	.2
	Groom Lake	14	.5	<.1	.2
	Hiko	31	.6	<.1	.2
	Indian Springs	31	.4	<.1	.2
	Las Vegas	20	.5	<.1	.2
	Lathrop Wells	31	.3	<.1	.1
	Lida	20	.3	<.1	.2
	Lovelock	3	<.1	<.1	.1
	Lund	29	.8	<.1	.2
	Mesquite	29	.5	<.1	.2
	Nyala	30	1.9	<.1	.2
	Pahrump	19	.2	<.1	.1
	Pioche	16	.4	<.1	.1
	Reno	13	.1	<.1	.1
	Round Mountain	31	.9	<.1	.2
	Scotty's Junction	31	.8	<.1	.2
	Stone Cabin Ranch	31	.8	<.1	.1
	Sunnyside	30	1.4	<.1	.2
	Tonopah	31	.6	<.1	.2
	Tonopah Test Range	17	.8	<.1	.2
	Warm Springs	30	.9	<.1	.2
	Warm Springs Ranch	31	.5	<.1	.2
	Wells	15	.6	<.1	.2
	Winnemucca	15	.8	<.1	.2
N. Mex:	Albuquerque	9	1.0	<.1	.3
	Carlsbad	13	.5	<.1	.1
Okla:	Muskogee	15	.8	<.1	.1
Oreg:	Burns	15	.2	<.1	.1
	Medford	6	.1	<.1	.1
S. Dak:	Aberdeen	11	.8	<.1	.3
	Rapid City	15	1.0	<.1	.2
Tex:	Abilene	15	.2	<.1	.1
	Amarillo	15	.6	<.1	.2
	Austin	7	<.1	<.1	.1
	Forth Worth	14	.5	<.1	.1
Utah:	Cedar City	27	1.2	<.1	.2
	Delta	30	1.0	<.1	.2
	Dugway	6	.1	<.1	.1
	Enterprise	16	1.3	<.1	.4
	Garrison	31	.8	<.1	.2

See footnotes at end of table.

Table 2.—Summary of gross beta radioactivity concentrations in air, July 1973—continued

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average
Utah:	Logan	15	1.3	<.1	.4
	Milford	30	1.3	<.1	.2
	Monticello	15	4.5	<.1	.4
	Parowan	16	1.3	<.1	.3
	Provo	16	1.3	<.1	.3
	Roosevelt	15	1.3	<.1	.2
	Salt Lake City	12	.8	<.1	.2
	St. George	31	1.0	<.1	.2
	Wendover	16	1.6	<.1	.3
Wash:	Seattle	15	<.1	<.1	.1
	Spokane	9	<.1	<.1	.1
Wyo:	Rock Springs	15	1.6	<.1	.4
	Worland	15	1.6	<.1	.2

3. Canadian Air and Precipitation Monitoring Program,[3] July 1973

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 4), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and

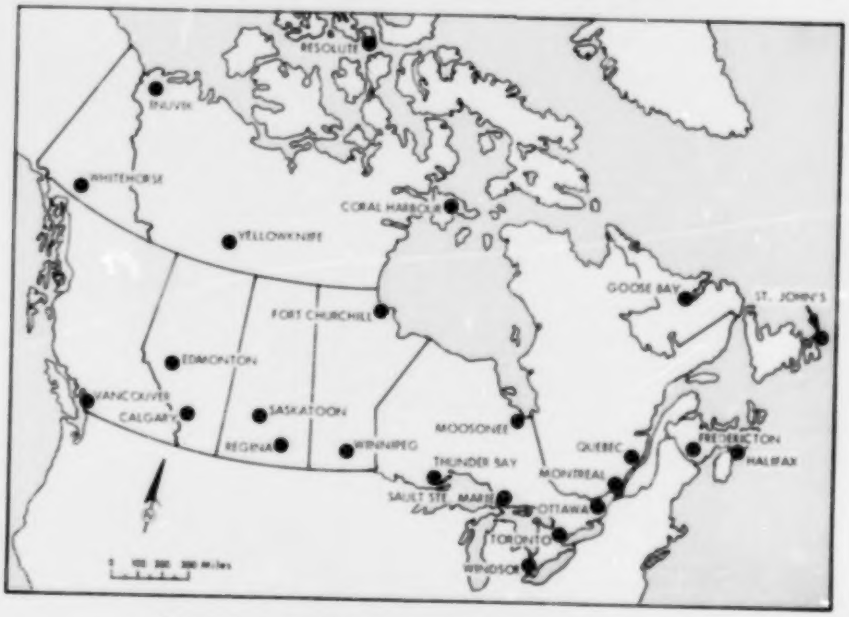
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
N
0 100 200 300 Miles

Figure 4. Canadian air precipitation monitoring area

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[3] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

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methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for July 1973 are presented in table 3.

Table 3. Canadian gross beta radioactivity in surface air and precipitation, July 1973

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	11	0.09	0.01	0.05	4	0.2
Coral Harbour	15	.05	<.01	.03	6	.9
Edmonton	10	.07	.01	.04	8	.1
Ft. Churchill	12	.02	<.01	.01	6	.6
Fredericton	13	.05	<.01	.03	11	.7
Goose Bay	14	.02	<.01	.02	4	.5
Halifax	15	.06	<.01	.03	4	.7
Inuvik	12	.04	<.01	.02	10	.4
Montreal	18	.04	<.01	.02	12	.9
Moosonee	11	.04	<.01	.02	1	.1
Ottawa	16	.11	<.01	.06	8	.3
Quebec	16	.04	<.01	.02	6	1.3
Regina	16	.04	<.01	.02	6	.3
Resolute	11	.03	<.01	.02	24	.5
St. John's, Nfld	12	.04	<.01	.02	9	.6
Saskatoon	11	.04	<.01	.02	12	.5
Sault Ste. Marie	19	.05	<.01	.03	13	1.1
Thunder Bay	15	.04	<.01	.02	12	1.9
Toronto	7	.03	<.01	.02	2	.1
Vancouver	9	.05	<.01	.03	96	.9
Whitehorse	11	<.01	<.01	<.01	8	.2
Windsor	8	.03	.01	.02	2	.2
Winnipeg	16	.06	.01	.04	12	1.4
Yellowknife	13	.04	<.01	.02	34	.9
Network summary	311	0.11	<0.01	0.03	13	0.6

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4. Pan American Air Sampling Program July 1973

Pan American Health Organization and U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The July 1973 air monitoring results from the participating countries are given in table 4.

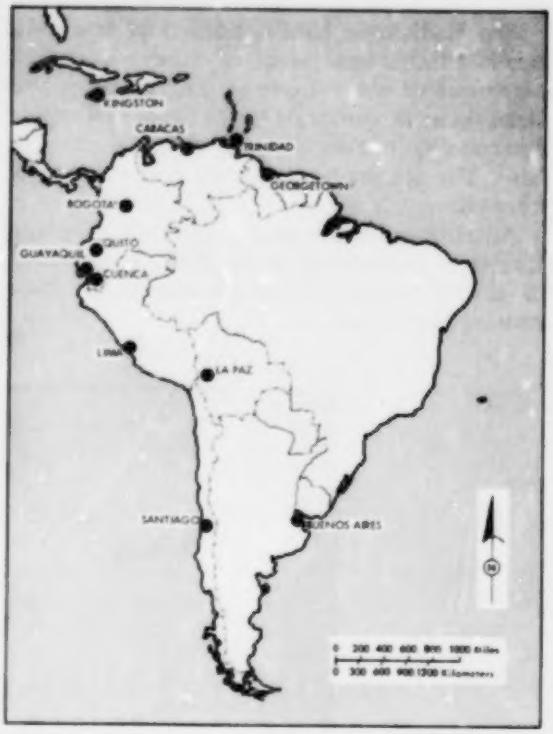

Figure 5. Pan American air sampling program stations

Table 4. Summary of gross beta radioactivity in Pan American surface air, July 1973

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	20	11.90	0.00	0.94
Chile:	Santiago	31	.05	.00	.02
Colombia:	Bogota	21	.05	.00	.01
Ecuador:	Cuenca	17	.01	.00	.00
	Guayaquil	17	.03	.00	.01
	Quito	0			
Guyana:	Georgetown	0			
Jamaica:	Kingston	0			
Peru:	Lima	26	.03	.00	.01
Venezuela:	Caracas	11	.03	.00	.02
West Indies:	Trinidad	10	.15	.03	.07
Pan American summary		153	11.90	0.00	0.14

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging 0.00 pCi/m³.

5. California Air Sampling Program July 1973

Radiologic Health Section
California State Department of Health

The Radiologic Health Section of the California State Department of Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 6.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Health where they are analyzed for their radioactive content.

Airborne particles are collected by a continuous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micrometer pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity, 72 hours after the end of the collection period. The daily samples are then composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. Table 5 presents the gross beta radioactivity in air for July 1973. The gamma results are presented quarterly.

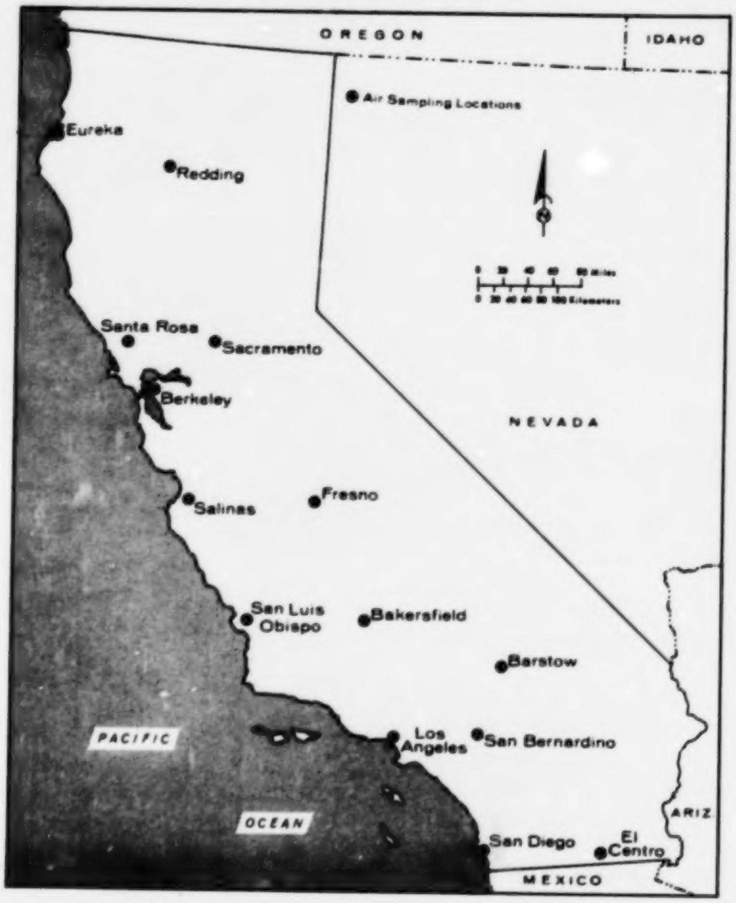
OREGON
IDAHO
● Air Sampling Locations
Eureka
Redding
Santa Rosa
Sacramento
Berkeley
NEVADA
Fresno
Salinas
San Luis Obispo
Bakersfield
Barstow
Los Angeles
San Bernardino
PACIFIC
OCEAN
ARIZ
San Diego
El Centro
MEXICO

Figure 6. California air sampling program stations

Table 5. Gross beta radioactivity in California air
July 1973

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	31	0.66	0.07	0.17
Barstow	31	.47	.03	.19
Berkeley	31	.17	.00	.04
El Centro	20	.39	.09	.21
Eureka	31	.12	.00	.03
Fresno	31	.46	.08	.16
Los Angeles	28	.12	.00	.05
Redding	29	.39	.05	.14
Sacramento	31	.53	.01	.10
Salinas	31	1.93	.02	.18
San Bernardino	31	.37	.04	.13
San Diego	31	.13	.02	.06
San Luis Obispo	31	.19	.00	.07
Santa Rosa	31	.17	.00	.07
Summary	418	1.93	0.00	0.11

REFERENCES

(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors annual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

A summary of the environmental radioactivity data follows for the Los Alamos Scientific Laboratory.

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[1] Title 10, Code to Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Los Alamos Scientific Laboratory[2]
Calendar Year 1971

University of California
Los Alamos, N. Mex.

The Los Alamos Scientific Laboratory, which is administered by the University of California for the U.S. Atomic Energy Commission (AEC), lies mostly in Los Alamos County, with only a small segment in Santa Fe County, and encompasses approximately 28,000 acres. This parcel of AEC controlled land contains all of the laboratory technical areas (figure 1).

The laboratory and community at Los Alamos are located on the Pajarito Plateau, situated west of the Rio Grande on the eastern slopes of the Jemez Mountains in north-central New Mexico. This location was originally chosen for its relative isolation. Thus the area surrounding Los Alamos, including all of Los Alamos County and large portions of Sandoval and Santa Fe Counties, is largely undeveloped except for those areas occupied by the laboratory facilities and the associated communities of Los Alamos and White Rock. Large tracts of land in the Jemez Mountains to the north, west, and south of the laboratory site are held by the Forest Service. This land is largely covered by fir and aspen forests which support the usual variety of western mountain wildlife. Agriculture is limited to home gardens with some grazing of beef cattle. In river valleys to the east, agriculture is restricted to relatively small plots supported by irrigation. Primary crops are chili peppers, beans, and tree fruits. Milk is not produced in commercial quantities in the immediate vicinity of Los Alamos. The technical areas are principally located on the mesa

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[2] Summarized from "Environmental Monitoring at Major U.S. Atomic Energy Commission Contractor Sites—Calendar Year 1971."

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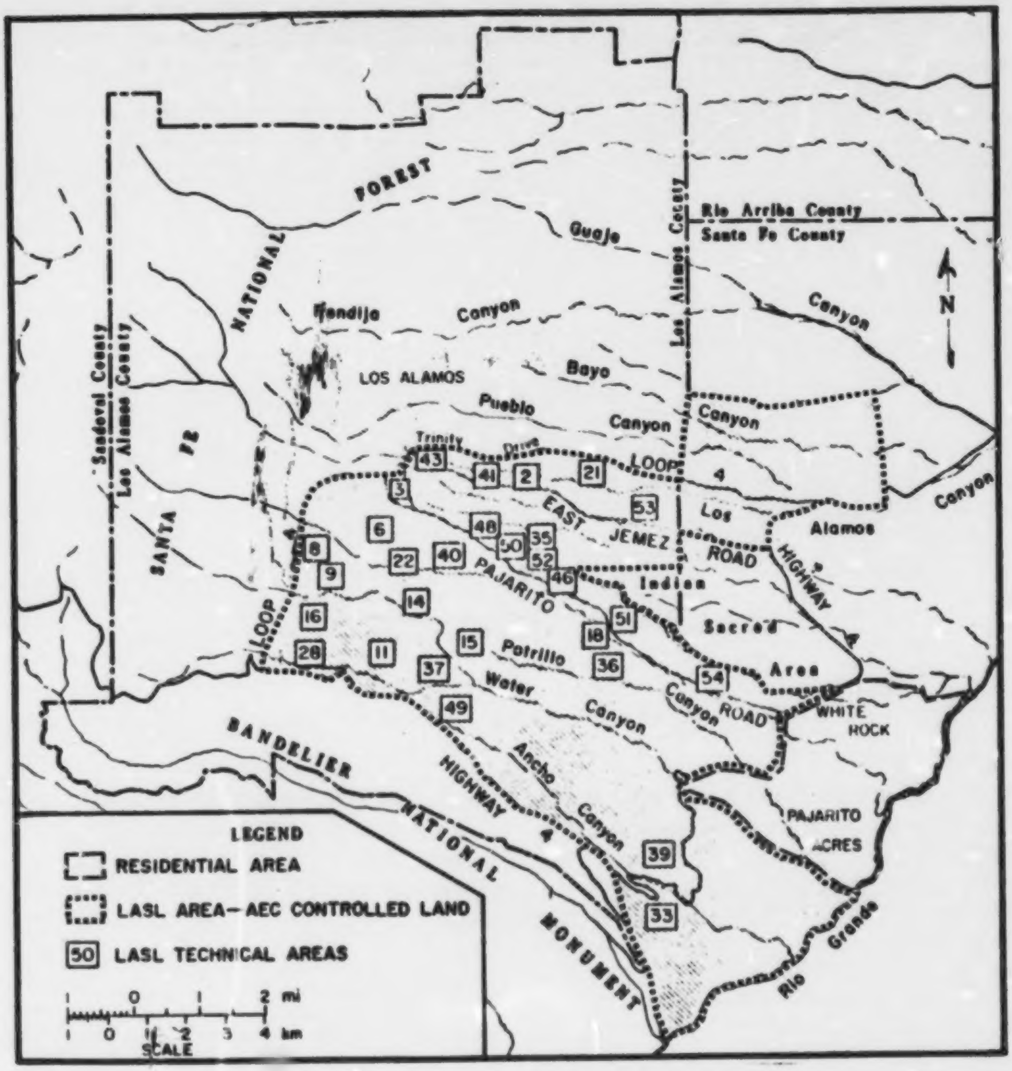
FOREST
NATIONAL
SANTA FE
Sandoval County
Los Alamos County
Los Alamos County
Rio Arriba County
Santa Fe County
N
Guaje
Canyon
Rendija
Canyon
LOS ALAMOS
Bayo
Pueblo
Canyon
Canyon
Trinity
Drive
LOOP
4
Los
Alamos
Canyon
EAST
JEMEZ
ROAD
HIGHWAY
4
PAJARITO
Indian
Sacred
Area
LOOP
Potrillo
Water
Canyon
Canyon
ROAD
WHITE
ROCK
Ancho
Canyon
HIGHWAY
4
BANDELIER
NATIONAL
MONUMENT
PAJARITO
ACRES
Rio
Grande
43
41
2
21
3
53
6
48
50
35
52
22
40
8
9
46
14
51
16
18
15
36
28
11
37
54
49
39
33
LEGEND
RESIDENTIAL AREA
LASL AREA—AEC CONTROLLED LAND
50 LASL TECHNICAL AREAS
0
1
2 mi
0
1
2
3
4 km
SCALE

Figure 1. Los Alamos county and LASL technical areas

tops with the interspersed canyons serving as separation areas, although a few have been located at the bottoms of steep, narrow canyons for isolation and safety purposes.

Gaseous effluents

Since the laboratory is a large, broadly diversified organization employing a few thousand personnel engaged in fundamental and applied research in the natural sciences with emphasis on nuclear materials, the facilities include literally hundreds of potential sources of airborne material. At present, processes which are known to have the potential for significant releases are controlled and monitored, but numerous laboratory hoods still exist where procedural controls are relied upon for proper utilization. However, it should be stressed that within this continually changing environment of research, the major potential sources of troublesome materials are confined to a few

Table 1. Summary of major airborne effluents, January-December 1971

January-June 1971

Technical area	Gross beta (μCi)	^{238}Pu, ^{239}Pu (μCi)	^{235}U (μCi)	U[a] (μCi)	^{131}I (μCi)	^{137}Cs (μCi)	^{41}Ar (Ci)	^{3}H (Ci)
3	600	5,900			6,100			5
21		970	350					2
2						560	710	
33								3,000
41								280
35								2,700
Other	900	40	90	180				

July-December 1971

Technical area	Gross beta (μCi)	^{238}Pu, ^{239}Pu (μCi)	^{235}U (μCi)	U[a] (μCi)	^{131}I (μCi)	^{88}Rb, ^{138}Cs (mCi)	^{41}Ar (Ci)	^{3}H (Ci)
2						26	860	
3	880	3,000	370	210	850			84
21		570	830					3
33								1,100
35		4						430
41		5						60
46			4					
48	990	14						
50	51	5						
Other				[b] 890				1,100

[a] Natural and depleted uranium. Does not include those amounts listed under uranium-235.

[b] Kilograms of depleted uranium. Mass spectrometer analysis of a typical sample indicates the composition to be (weight percent):

Uranium-234, 0.0006 percent
Uranium-235, .1925 percent
Uranium-236, .0036 percent
Uranium-238, 99.803 percent

An estimate of the uranium activity only (excluding daughters) for 890 kg is 0.33 Ci.

well-known locations. The major sources of airborne contaminants at the laboratory are summarized in table 1.

Certain tests with conventional explosives involve the dispersal into the atmosphere of kilogram quantities of depleted uranium and occasional small quantities of tritium and nonradioactive metals such as lead, copper, beryllium, aluminum, and cadmium. The amounts of materials given for these tests are not the amounts actually dispersed into the atmosphere; significant fractions remain in the immediate vicinity of the test site. The magnitudes of these fractions will be studied later.

The increase in rubidium-88 and cesium-138 from the TA-2 reactor site in July-December 1971 over that reported in January-June was almost entirely due to a single release in December when a valve in the stack discharge line failed. To document the environmental consequences of this release, filters from selected downwind weekly air samplers were collected and analyzed. No activity attributable to this release was found on any of the weekly filters or on the filter from the daily air sampler collected that day. The excess tritium released from TA-3 was due to the rupture of several targets at the tandem Van de Graaff accelerator facility.

Liquid effluents

Cooling water and sanitary sewage comprise the majority of the liquid effluent streams at the laboratory. Again, processes which are known to have the potential for significant releases are controlled and monitored, but numerous drains exist where procedural controls are relied upon for proper utilization.

The effluents are released into canyons that contain intermittent streams. The effluents recharge water in the alluvium that is depleted by evaporation or transpiration and do not reach the Rio Grande. None of the effluent streams recharge aquifers from which municipal, industrial, or irrigation water is drawn.

The primary sources of potentially contaminated liquid effluent from laboratory operations

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are from the industrial liquid waste treatment plant at TA-21 and from the central industrial liquid waste treatment plant at TA-50. Effluents from the TA-21 plant are released into DP canyon that is tributary to Los Alamos Canyon, and those effluents from TA-50 are released into Effluent Canyon, which is tributary to Mortandad Canyon. Water is released with concentrations lower than those listed in table 2, AEC Manual Chapter 0524, but evaporation and adsorption tends to concentrate the contamination in the channel alluvium. The amounts of radionuclides released from these two sources are shown in table 2.

Table 2. Summary of major liquid effluents January-December 1971

Contaminant	January-June 1971		July-December 1971	
	TA-21 (mCi)	TA-50 (mCi)	TA-21 (mCi)	TA-50 (mCi)
Gross alpha	[a] 0.43	5.85	[b] 0.28	5.0
Gross beta		768.51		320
Plutonium-238	[a] .43	3.81	.10	2.6
Plutonium-239			.18	.47
Strontium-89	([c])	[c] 28.02	4.6	.08
Strontium-90			12	.11

[a] All alpha activity assumed to be due to plutonium.

[b] All alpha activity is assumed to be due to plutonium, although as much as 10 percent may be due to americium-241 for individual discharges.

[c] Several spot analyses indicated a ratio of 52:48 for strontium-89: strontium-90.

Solid waste disposal

Solid wastes, consisting mostly of contaminated sludges from the industrial waste treatment plants and potentially contaminated trash from routine laboratory operations, are buried in pits at TA-54 on the Mesita del Buey (a location chosen in cooperation with the U.S. Geological Survey to assure long time localization of radioactive materials) and in lined disposal shafts at TA-21. When appropriate, wastes are stabilized in concrete or other material prior to or during burial. The quantities of materials placed in storage during this period are given in table 3.

The quantity of radioactive material in the laboratory trash and equipment is not estimated because it is below the limits of detection for any device for the measurement of gross activity; however, it should be relatively low compared to that in the sludge. In addition, one batch of waste containing about 9 grams of plutonium was placed in a shaft at the burial site and embedded in concrete.

Routine monitoring programs

Several routine monitoring programs are carried out to provide information on the potential radiation doses to people in the environs and on the possible accumulations of radioactive or nonradioactive materials. The results of these programs are relayed immediately to the responsible operations so that any undesirable conditions may be immediately corrected.

Station locations are chosen to provide the geographic coverage desired for each type of measurement, with constraints imposed by physical accessibility and by availability of power. Similarly, collection dates are chosen to give a sampling frequency adequate for each type of measurement, with accessibility and distance from the laboratory being the major constraining factors. Those stations which are within the laboratory boundaries are listed in the tables as "onsite", and those which are outside of these boundaries are designated as "offsite."

Air monitoring

The air monitoring program is designed to provide for general surveillance of the levels of gross alpha and beta radioactivity in air, the concentrations of those specific radionuclides directly associated with laboratory operations and the concentrations of certain nonradioactive materials.

A high volume air sampler drawing air through an MSA Type BM2133 filter cartridge and a charcoal canister at the rate of approximately 400 liters per minute was maintained on the roof of the Occupational Health Laboratory (TA-3). A second charcoal canister was operated on a similar high volume sampler at the waste treatment facility (TA-50) during January–June 1971. The filter and the canister were changed daily. The particulate material on the filters is measured for gross beta emission twice, immediately and 8 days after collection, on an alpha-beta gas-flow proportional

Table 3. Summary of solid waste disposal, January-December 1971

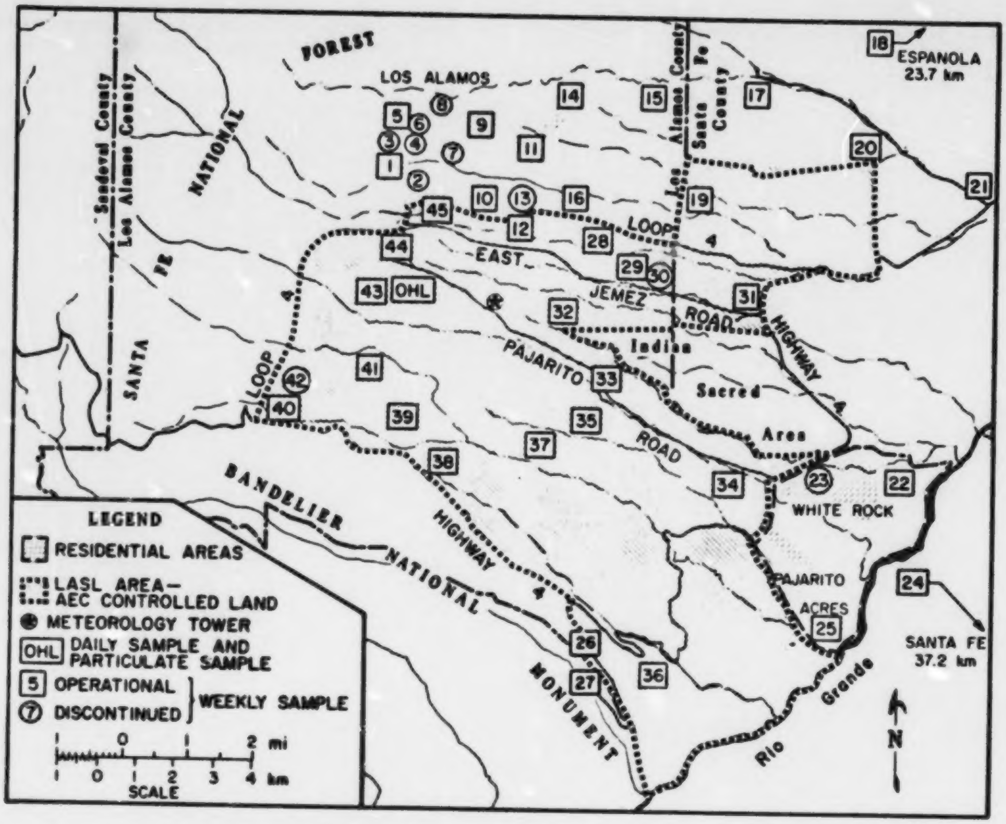
Burial site	Nature of waste	Container or stabilizer	Estimated volume (liters)	Estimated activity (Ci)
January-June 1971:				
TA-54	^{239}Pu sludge from TA-50	55 gallon steel barrels	84,800	2.6
TA-54	^{3}H	Metal containers filled with asphalt	80	6,400
TA-54	Trash		1,260,000	Trace
TA-54	Equipment		885,000	Trace
TA-54	Fission products and activated metal	Disposal shafts	134	120
TA-21	^{239}Pu sludge from TA-21	201,690 liters cement paste in lined disposal shafts	117,020	156
TA-21	Fission products			.4
July-December 1971:				
TA-54	Classified	Steel drums, 30 and 55 gallons	71,000	Not estimated
TA-54	Hot cell wastes, activated metal, wastes containing fission products	Metal containers	175	120
TA-54	Contaminated sludge from TA-50 liquid waste treatment plant	Steel drums, 55 gallons	42,000	1.9
TA-54	Air exhaust filters	Wooden boxes	18,100	.6
TA-54	Laboratory trash and scrap	Bags, boxes, crates, drums	2,300,000	Not estimated
TA-54	Wastes containing ^{238}Pu	Steel drums, 55 gallons	42,000	180
TA-21	Contaminated sludge from TA-21 liquid waste treatment plant	Cement paste	25,000	180

counter. The activity collected by the canister is measured by gamma ray spectrometry with emphasis on the iodine-131 determination. The initial measurement of the gross beta is taken to give early warning of large changes which would be apparent above the natural radon-thoron background fluctuations. The primary record of the activity is established by the 8-day measurement. The results in general are comparable with those samplers operated elsewhere in the country by the Environmental Protection Agency (EPA).

The main air monitoring network consists of an array of air sampling stations whose samples are collected weekly. During the period covered by this report, several new stations were added and several were deleted from the past network expanding the total number in operation from 23 in January to 35 in December. The locations of these stations as of the end of the period are given in figure 2. Each station consists of a pump which pulls air through a 50 mm membrane filter with a pore size of 1.2 μm and, at 12 stations, a charcoal cartridge for iodine collection at a rate of about 55 liters/min. In July, the filter was changed to a 78-mm Microsorban filter having an efficiency of about 99.8 percent for 0.3 μm di-octylphthalate (DOP) particles (a standard test aerosol for determining filter efficiency) and an 80-mm Welsh charcoal respirator cartridge at a flow rate averaging about 75 liters/min. These filters were measured for gross alpha and gross beta emitters on a gas-flow proportional counter, 1 day after collection and 8 days after collection. The filters from each station are then pooled to form a monthly composite sample which is analyzed radiochemically for plutonium and fluorometrically for uranium. An alpha spectrometer is used to allow resolution of plutonium-238 and plutonium-239. The charcoal cartridges are collected weekly and analyzed for iodine on a gamma ray spectrometer. In addition, the stations collect a separate weekly sample by drawing air through a tube of silica gel desiccate at an average flow of about 50 ml/min. This arrangement permits water vapor collection at about 95-percent efficiency. Water samples are obtained by heating the desiccate and condensing the resulting vapor. A standard aliquot of this water is measured for tritium content by liquid scintillation counting. This measurement is combined with the average humidity for the week to obtain an estimate of the average tritium concentration in air.

The gross alpha and gross beta activities are measured primarily for the purpose of screening the samples to insure against unexpectedly high concentrations of radionuclides which are not covered by the more specific analyses. A summary of the results of the measurements taken after 8 days decay is given in table 4 for January–December 1971.

The gross alpha measurements have been corrected both for background of the counting chamber and for the approximately 0.1 percent


FOREST
LOS ALAMOS
NATIONAL
SANTA
FE
Sandoval County
Los Alamos County
Los Alamos County
Santa Fe County
ESPANOLA
23.7 km
EAST
JEMEZ
ROAD
LOOP
4
HIGHWAY
4
PAJARITO
ROAD
Indian
Sacred
Area
LOOP
4
WHITE ROCK
PAJARITO
ACRES
SANTA FE
37.2 km
BANDELIER
NATIONAL
MONUMENT
HIGHWAY
4
Rio
Grande
N
OHL
1
2
3
4
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6
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LEGEND
RESIDENTIAL AREAS
LASL AREA–
AEC CONTROLLED LAND
METEOROLOGY TOWER
OHL DAILY SAMPLE AND PARTICULATE SAMPLE
5 OPERATIONAL
7 DISCONTINUED
WEEKLY SAMPLE
1
0
1
2 mi
1
0
1
2
3
4 km
SCALE

Figure 2. Locations of atmospheric monitoring stations, Los Alamos

of the beta counts that feed into the alpha channel of the counter ("cross-talk"). Due to erratic behavior of the counter during January–June, a detection limit could not be derived from considerations of the analytical procedure and the counting system. Instead, statistical analyses of the analytical results were used to estimate this detection limit. The entire group of samples (all stations and all times) were used to derive the detection limit for individual samples (maximum column), and only activities which lie more than 2.326 standard deviations above the mean (99-percent confidence level) were considered to be detectable. This procedure led to the value of 5 fCi/m^3 given in the table. A similar procedure, but considering the number of samples collected at each station, was used to arrive at the estimate of 2 fCi/m^3 for the detection limit for station averages. During July–December, the background was determined to be 0.2 counts per minute. A filter from the sampling array can thus be distinguished from the blank if it contains a total activity of more than 0.3 counts/min. Consideration of total flow through the filter yields a minimum detectable level of about 0.2 fCi/m^3 for the total collection and analysis procedure. This value is subject to variation due to fluctuations in sampling rate.

The gross alpha and beta emitters varied with time as expected from the seasonal variation of fallout with no real difference between the stations indicating that the activity was, within the error of the measurement, due to long term fallout from past weapons tests.

A summary of the results of the plutonium analyses performed on the monthly composites of the weekly air filters is given in table 5. The

Table 4. Results of gross measurements on weekly air filters, January-December 1971

Station	Number of samples	Concentration (fCi/m³) Gross alpha Maximum	Gross alpha Average	Gross beta Maximum	Gross beta Average
January-June 1971					
Offsite:					
2	11	<5	<2	1,100	520
3	23	<5	<2	1,800	610
4	22	<5	<2	1,400	510
5	23	<5	<2	2,100	640
6	22	5.5	<2	1,700	570
7	23	<5	<2	2,300	620
8	11	<5	<2	1,700	810
9	22	<5	<2	1,600	550
10	18	<5	<2	2,200	560
11	23	<5	<2	2,100	660
13	23	<5	<2	2,100	610
14	23	6.7	<2	1,300	580
15	23	7.5	<2	2,100	760
16	22	<5	<2	1,400	570
17	23	5.0	<2	1,400	570
18	11	8.3	<2	1,800	100
20	21	<5	<2	1,500	500
21	21	<5	<2	1,000	330
23	23	<5	<2	1,900	680
24	11	12	<2	1,400	870
25	12	5.5	<2	2,000	1,030
Onsite:					
30	22	7.4	<2	1,000	480
36	22	<5	<2	1,900	680
38	23	<5	<2	1,900	580
42	22	<5	<2	1,000	470
44	22	<5	<2	2,400	780
45	23	<5	<2	1,800	610
Detection limit:		See text		10	

average values are generally in line with the concentrations of plutonium-239 reported by the Environmental Protection Agency as occurring from worldwide fallout. For example, reported values for Denver are 55 aCi/m³ and 125 aCi/m³ for the first and second 3-month periods of 1971, respectively (*1, 2*). In view of this correspondence and the lack of difference between the individual sampling stations, it is concluded that plutonium-239 concentrations listed are primarily due to fallout with no detectable contribution from the laboratory.

The only significant station effect in the plutonium-239 concentrations occurred at station 44 (Administration Building). Because the plutonium-238 concentration also was high at this station, both high measurements are attributed to the CMR building airborne effluents. All other plutonium-239 concentrations fall within the range of values attributable to worldwide fallout (*1*) and exhibit the same increase or decrease with time as did the gross alpha and gross beta concentrations.

Table 4. Results of gross measurements on weekly air filters, January-December 1971—continued

Station	Status[a]	Number of samples	Gross alpha Concentration (fCi/m³) Maximum	Gross alpha Average	Gross beta Concentration (fCi/m³) Maximum	Gross beta Average[b]
July-December 1971						
Offsite:						
1	N	24	7.3	1.3 ± 0.7	400	130 ± 40
2	D	2	1.4	1.0 ± 5.0	140	120 ± 200
3	D	13	7.0	1.4 ± 1.1	360	190 ± 60
4	D	2	1.7	1.2 ± 6.2	300	240 ± 780
5	N	14	1.2	.6 ± .2	230	100 ± 30
6	D	2	1.7	1.6 ± 1.9	310	310 ± 10
7	D	2	2.1	1.7 ± 4.9	380	300 ± 100
8	D	13	5.0	1.3 ± .8	420	220 ± 80
9	N	24	5.2	1.0 ± .5	410	130 ± 40
10	C	27	9.4	1.1 ± .7	370	140 ± 40
11	C	27	5.2	1.1 ± .4	360	140 ± 40
12	C	27	10	1.1 ± .7	400	140 ± 40
13	D	2	2.3	1.9 ± 5.6	360	340 ± 340
14	C	27	3.5	1.1 ± .3	450	140 ± 40
15	C	27	8.5	1.2 ± .6	440	170 ± 50
16	C	27	9.1	1.2 ± .7	400	140 ± 40
17	C	27	5.5	1.1 ± .4	410	150 ± 40
18	C	27	6.9	1.4 ± .5	550	170 ± 50
19	N	16	31	2.6 ± 4.0	220	90 ± 20
20	C	27	5.7	1.1 ± .4	390	150 ± 40
21	C	27	1.9	.7 ± .2	270	100 ± 20
22	N	14	2.0	.7 ± .3	230	110 ± 30
23	D	13	5.9	1.5 ± .9	430	200 ± 70
24	C	<25	4.0	1.6 ± .4	350	160 ± 40
25	C	27	6.0	1.1 ± .5	400	150 ± 50
26	N	8	0.9	.3 ± .2	220	90 ± 50
27	N	8	2.9	.6 ± 8	240	90 ± 50
Onsite:						
28	N	17	1.5	.5 ± .2	210	70 ± 20
29	N	9	14	2.1 ± 3.5	220	100 ± 50
30	D	10	5.4	1.6 ± 1.1	440	170 ± 100
31	N	17	1.1	.5 ± .2	220	90 ± 20
32	N	8	1.0	.3 ± .3	360	120 ± 100
33	N	17	2.0	.7 ± .3	180	90 ± 20
34	N	17	1.4	.5 ± .2	120	70 ± 10
35	N	18	2.3	.8 ± .3	220	80 ± 20
36	C	27	3.2	.8 ± .3	390	120 ± 40
37	N	16	1.5	.6 ± .3	220	100 ± 20
38	C	27	5.2	1.1 ± .5	430	160 ± 50
39	N	16	5.1	1.0 ± .7	230	100 ± 20
40	N	15	2.1	.8 ± .4	260	100 ± 30
41	N	16	1.4	.5 ± .2	220	90 ± 20
42	D	12	3.4	1.3 ± .6	330	210 ± 70
43	N	8	.9	.4 ± .3	250	100 ± 50
44	C	27	11	1.7 ± .9	440	160 ± 40
45	C	27	8.1	1.1 ± .6	290	130 ± 30

[a] Status: N, new station initiated this report period; D, old station discontinued this report period; and C, old station continuing in operation.
[b] Average and 95-percent confidence limits for the average.
[c] Includes two 2-week samples.

All future plutonium effluents will be decreased. Measures are underway to improve the filtration of the exhaust from the CMR building. This work should reduce the effluents by several orders of magnitude and is expected to be completed by mid 1973. A new and improved plutonium processing facility to replace the one at TA–21 is in the conceptual design stage.

Analysis of the charcoal cartridges indicated that iodine-131 could not have been present at

Table 5. Plutonium concentrations in air January-December 1971

Station	Number of samples	Concentration (aCi/m³)			
		Plutonium-239		Plutonium-238	
		Maximum	Average	Maximum	Average
January-June 1971					
Offsite:					
2	5	130	85	1,100	280
3	6	140	79	47	16
4	6	150	81	26	16
6	6	130	84	35	14
7	6	160	98	48	31
8	6	170	92	18	13
9	3	360	180	88	60
10	6	150	100	210	48
11	5	160	96	95	34
12	6	150	100	35	17
13	6	160	97	53	20
14	6	130	69	31	20
15	6	150	94	70	30
16	6	140	89	22	12
17	6	160	88	61	23
18	3	180	140	22	20
20	6	98	67	35	18
21	6	160	64	39	18
23	6	160	91	44	19
24	3	170	120	7	5
25	3	130	120	32	15
Onsite:					
30	6	130	69	35	19
36	6	160	100	31	17
37	6	130	95	74	30
42	6	140	87	22	12
44	6	280	190	280	130
45	6	150	96	93	48
Detection limit		10		10	

concentrations above 10 fCi/m³, the estimated MDL of the system.

Stations to the north and east of the locations where plutonium-238 releases occurred (TA-2 and the Chemistry and Metallurgy Research Building in TA-3) exhibited concentrations generally higher than the average of all other stations to the south and the distant stations in Santa Fe and Espanola. This result again is consistent with the wind patterns in Los Alamos over the 6-month period.

The maximum observed onsite plutonium-238 concentration, 280 aCi/m³ at station 44 (Administration Building), was only 14 percent of 2 pCi/m³ concentration guide value for the soluble form of the isotope as given in AEC Manual Chapter 0524 for occupational exposure. Public traffic on adjacent roads is normally permitted, and the boundary of the laboratory is near this station. A comparison to the 70 fCi/m³ concentration guide for an individual in the general public indicates that the maximum concentration is less than 0.4 percent of this guide. During January–June, only station 9 showed a concentration significantly higher than the average. This concentration, 88 aCi/m³, was only 0.1 percent of the AEC standard. The maximum offsite concentration, 85 aCi/m³ at station 12 (Museum), was approximately 0.1 percent of this same guide value. An unusually high concentration (1.1 fCi/m³) occurred at station 2 in the town of Los Alamos. It was an order of magnitude higher than all other monthly samples, and no explanation can be given for it. The unusually high concentration of 5.9 fCi/m³ recorded at station (Bayo Canyon Sewage Treatment Plant) during July–December, is nearly two orders of magnitude higher than all other measurements made during the 12-month

Table 5. Plutonium concentrations in air January-December 1971—continued

Station	Status[a]	Number of samles	Concentration (aCi/m³)			
			Plutonium-239		Plutonium-238	
			Maximum	Average	Maximum	Average
July-December 1971						
Offsite:						
1	N	6	55	30 ± 20	10	5 ± 3
3	D	3	70	48 ± 47	40	23 ± 36
5	N	4	25	15 ± 12	13	6 ± 8
8	D	1	15	—	35	—
9	N	6	80	37 ± 27	25	12 ± 8
10	C	7	65	42 ± 16	55	25 ± 18
11	C	7	40	21 ± 14	45	18 ± 16
12	C	7	45	28 ± 11	85	29 ± 27
14	C	7	80	41 ± 18	30	13 ± 19
15	C	7	65	37 ± 19	40	18 ± 12
16	C	7	65	35 ± 13	40	15 ± 13
17	C	7	55	30 ± 19	15	7 ± 4
18	C	7	32	20 ± 9	32	10 ± 9
19	N	5	200	[c]23 ± 36	5,900	[c]26 ± 58
20	C	7	90	40 ± 25	45	15 ± 15
21	C	7	36	24 ± 09	55	17 ± 17
22	N	4	32	25 ± 12	23	11 ± 14
23	D	3	45	30 ± 37	20	12 ± 20
24	C	7	60	40 ± 10	40	13 ± 12
25	C	7	100	37 ± 27	27	14 ± 9
26	N	3	26	21 ± 23	51	19 ± 68
27	N	3	48	32 ± 35	24	13 ± 26
Onsite:						
28	N	5	28	18 ± 12	19	11 ± 8
29	N	3	130	57 ± 150	19	9 ± 22
30	D	2	40	28 ± 160	20	13 ± 95
31	N	5	46	28 ± 18	25	12 ± 11
32	N	3	43	25 ± 40	25	14 ± 26
33	N	5	29	21 ± 11	34	17 ± 16
34	N	5	55	18 ± 26	30	11 ± 14
35	N	5	24	17 ± 7	20	10 ± 8
36	C	7	75	33 ± 23	38	16 ± 12
37	N	5	40	31 ± 13	20	11 ± 8
38	C	7	50	26 ± 14	25	16 ± 8
39	N	5	95	39 ± 47	15	8 ± 6
40	N	4	33	23 ± 16	24	10 ± 15
41	N	5	120	39 ± 58	15	8 ± 7
42	D	3	55	27 ± 61	20	10 ± 22
43	N	3	34	29 ± 12	20	12 ± 20
44	C	7	330	170 ± 1[illegible]0	140	65 ± 52
45	C	7	180	45 ± 58	100	32 ± 32

[a] Status: N, new station initiated this report period; D, old station discontinued this report period; and C, old station continuing in operation.

[b] Average and 95-percent confidence limits for the average.

[c] Average and confidence interval do not include the high value.

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period and is not completely understood. It appears that one of these anomalously high values occurs about every 6 months at one of the weekly air sampling stations.

The measurements of tritiated water vapor in air are summarized in table 6. Analysis of the data indicates that there were significant differences between sampling stations. The onsite sampling stations, located closer to the areas where tritium releases occurred, indicated atmospheric concentrations higher than those measured by the samplers in the surrounding county, and these, in turn, showed levels above those in Santa Fe and Espanola. If the levels in Santa Fe and Espanola can be considered to be representative of the background tritium concentrations due to worldwide fallout, then the concentrations in the communities in Los Alamos County appear to be about twice background, and the concentrations at some of the onsite locations are about 10 times background. The average offsite concentrations, including background, in the Los Alamos area are about 0.08 percent of the concentration guide of 0.2 nCi/liter as given in AEC Manual Chapter 0524 for individuals in the population or about 0.2 percent of the recommended guide for population groups. The average concentrations at the onsite stations are about 0.01 percent of the recommended guide for controlled areas (5 nCi/liter).

Precipitation monitoring

Deposition is measured on a daily basis using a precipitation collector 0.4 m² in area located at the waste treatment plant (TA-50). The collector is rinsed with water and the rinse water is combined with whatever precipitation may have been collected. The sample is filtered, the water is evaporated to dryness and the filter is

Table 6. Summary results for tritium analyses of weekly air samples, January-December 1971

Station	Number of samples	Concentration (pCi/m³)	
		Maximum	Average
January-June 1971			
Offsite:			
1	20	420	100
11	20	450	160
15	20	200	70
16	20	400	140
18	11	140	50
21	20	600	110
23	20	240	110
24	11	140	60
Onsite:			
36	20	3,400	750
38	20	2,200	220
44	20	1,600	330
11	20	2,200	630
Detection level		20	

Station	Status[a]	Number of samples	Concentration (pCi/m³)	
			Maximum	Average[b]
July-December 1971				
Offsite:				
1	N	23	110	34 ± 10
5	N	13	80	26 ± 11
9	N	23	82	37 ± 9
10	N	21	83	37 ± 9
11	C	27	190	50 ± 18
12	C	27	240	74 ± 21
14	N	22	400	59 ± 40
15	C	27	110	33 ± 8
16	C	27	740	120 ± 60
17	N	19	67	22 ± 6
18	C	27	100	33 ± 10
19	N	16	200	36 ± 25
20	N	19	94	27 ± 10
21	C	27	150	43 ± 13
22	N	14	55	20 ± 6
23	D	13	140	76 ± 24
24	C	27	80	31 ± 7
25	N	14	220	32 ± 31
26	N	8	53	30 ± 12
27	N	8	89	30 ± 25
Onsite:				
28	N	17	320	85 ± 47
29	N	8	460	79 ± 130
31	N	17	930	95 ± 110
32	N	8	140	62 ± 39
33	N	17	310	59 ± 39
34	N	17	300	54 ± 37
35	N	18	120	38 ± 16
36	C	27	1,800	240 ± 140
37	N	16	760	82 ± 99
38	C	27	920	74 ± 67
39	N	16	190	42 ± 23
40	N	15	33	19 ± 4
41	N	16	100	45 ± 14
43	N	8	73	36 ± 21
44	C	27	230	76 ± 21
45	N	21	120	43 ± 13

[a] Status—N, new station or old station fitted with moisture collector this report period; D, old station discontinued this report period; C, old station continuing in operation.

[b] Average and 95 percent confidence limits for the average.

wet ashed. The two resulting planchets are measured separately on the Widebeta counter for gross beta activity, and the total beta activity is obtained arithmetically. Again measurements are taken immediately and after 8 days with the 8-day measurement considered to represent the gross emitters free of the interfering daughters of radon and thoron. Again, an increase in the earlier spring and a decrease in the fall and winter was noted although this trend is considerably obscured by fluctuations due to scavenging by natural precipitation.

External radiation monitoring program

A thermoluminescent dosimeter (TLD) array is maintained to monitor gamma and x radiation at natural background levels to provide information on any possible contribution due to laboratory activities. To improve the quality of the data from this array, substantial changes in equipment, location, and procedure were affected this reporting period.

During the first half of the year, the array used two TLD's at each station. One was the EG&G Model TL-2B consisting of a CaF_2:Mn powder chemically bonded to a heating coil and enclosed in an evacuated glass envelope; the other was the MBLE consisting of CaF_2:(unknown activator) bonded to a heating cylinder and enclosed in an evacuated glass envelope. Two sets of each were maintained and swapped for reading at approximately 30-day intervals. A summary of the results is given in table 7. Both types suffered from an inherent natural dosimeter background, presumably due to naturally occurring radioisotopes in the binder and glass envelope. This source normally contributed 3 to 5 times the external dose intended to be measured and made interpretation and evaluation of the measurements very difficult. In addition, unexplainable discrepancies in readings from the two dosimeters at each station occasionally occurred.

We, therefore, decided to replace both types of TLD's with Harshaw TLD-100 LiF chips (natural lithium). This system was chosen because LiF exhibits negligible dosimeter background and fading characteristics, tissue equivalence, and uniform energy response. Although this system lacks the sensitivity of the CaF_2:Dy system, its fading and energy response characteristics are better. Increasing the high voltage on an Eberline TLR-5 reader produces approximately 60 net counts above a 20- to 25-count background for a 10-mR dose to the TLD's. This is approximately the dose received at a typical station in the TLD array.

Due to delays in acquisition, the TLD-100 chips were not available for placement in July. The operational necessity to field a set of TLD's to maintain continuity led to the placement of 55 Harshaw TLD-700 chips that were available for other purposes. Both TLD-700 and TLD-100 chips are LiF chips, but in this case the lithium is depleted in lithium-6. For comparison, 39 EG&G and 41 MBLE TLD's were placed with the TLD-700 chips, and the results of this placement are given in table 7. Continued acquisition delays led to further complications in August. Not enough TLD-700 chips were available to allow for placement of fresh TLD's while

Table 7. Thermoluminescent dosimeter readings, January-December 1971

Month	EG & G dosimeters				MBLE dosimeters				Harshaw			
	Offsite		Onsite		Offsite		Onsite		Offsite		Onsite	
	Number of stations	(mR/day)	Number of stations	(mR/day)	Number of stations	(mR/day)	Number of stations	(mR/day)	Number of stations	(mR/day)	Number of stations	(mR/day)
January	20	[a]0.50 ±0.13	37	0.53 ±0.13	20	0.20 ±0.12	37	0.21 ±0.12				
February	22	.44 ± .11	37	.52 ± .11	22	.20 ± .10	37	.21 ± .09				
March	21	.29 ± .11	36	.31 ± .09	21	.20 ± .10	37	.21 ± .12				
April	21	.20 ± .09	37	.28 ± .12	21	.18 ± 10	37	.21 ± .13				
May	22	.26 ± .10	35	.31 ± .09	22	.26 ± .12	37	.31 ± .15				
June	21	.24 ± .14	34	.31 ± .12	20	.22 ± .11	36	.24 ± .09				
July	12	.47 ± .07	27	.47 ± .05	13	.14 ± .07	28	.12 ± .04				
August	23	.18 ± .05	31	.26 ± .07	23	.20 ± .04	31	.18 ± .03	22	0.12 ±0.03	33	0.14 ±0.01

[a] Average and 95-percent confidence limits for the average.

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reading those that had been in the field. Therefore MBLE and EG&G TLD's were again fielded in August, and the results of this placement also are given in table 7.

The Harshaw TLD–100 TLD's were finally put into service on August 25, 1971. The configuration of the station array was revised slightly to provide more uniform coverage.

Each station consists of three TLD chips in a single container. The TLD's are exchanged for fresh ones and read at 28-day intervals, and the average of the three readings for each station is taken to be the dose at that station for that period.

A summary of these measurements is given in table 8. There were five measurement intervals during the last part of the report period. Occasionally, a TLD package was missing at collection time causing the number of measurements to be less than five. Station 35 was discontinued during the report period but will be reinstated.

In general, the TLD measured dose decreased over the 6-month period. The average for all offsite stations was 10.8 mR per 28-day interval, and the corresponding number for all onsite stations was 11.6 mR, neglecting station 33 (TA–18) whose response was due to the programmed operation of a fast burst reactor at TA–18. The readings for two offsite stations, number 11, Los Alamos Airport, and number 22, Bandelier Headquarters, and one onsite station, number 38 (TA–39), were slightly higher than the onsite and offsite averages. For comparison purposes, TLD-measured dose at Colorado Springs (6,170-foot elevation) for an equivalent period was about 11.3 mR and points closer to sea level (<1,000-foot elevation) were reported as 2 to 6 mR (*3*). The Los Alamos averages seem to be consistent with doses expected from solar radiation at this elevation.

Table 8. Summary of thermoluminescent dosimeter readings, January-December 1971

Stations	Number of readings	Dose (mR)	
		Maximum	Average[a]
Offsite:			
1	5	12.1	10.1 ± 2.1
2	5	13.2	10.6 ± 2.7
3	5	13.1	10.2 ± 2.2
4	5	11.8	10.7 ± 1.8
5	5	12.0	10.8 ± .9
6	5	15.4	13.6 ± 2.5
7	5	10.9	9.8 ± 1.1
8	5	11.4	9.7 ± 1.5
9	5	15.6	11.4 ± 3.2
10	5	11.5	10.7 ± .8
11	5	17.2	14.2 ± 3.1
12	5	10.7	10.0 ± .6
13	4	10.3	8.5 ± 2.1
14	5	16.6	13.5 ± 2.6
15	5	11.6	10.3 ± 1.6
16	5	11.2	10.0 ± 1.2
17	5	11.9	10.4 ± 1.1
18	5	11.3	9.3 ± 1.6
19	4	11.4	8.8 ± 3.6
20	4	10.2	8.9 ± 2.1
21	5	11.6	10.5 ± 1.3
22	5	19.1	14.8 ± 3.5
Onsite:			
23	5	11.3	10.2 ± 1.0
24	5	16.5	13.6 ± 2.4
25	5	14.0	10.8 ± 3.5
26	5	12.7	11.0 ± 1.2
27	5	13.0	10.7 ± 2.0
28	3	12.9	11.4 ± 5.2
29	5	14.0	12.8 ± 1.6
30	5	12.2	10.5 ± 1.2
31	5	15.8	12.9 ± 2.3
32	5	13.7	12.5 ± 1.6
33	5	34.1	21.8 ± 10.1
34	5	13.4	12.1 ± 1.6
35	1	15.9	—
36	5	14.9	12.9 ± 2.0
37	4	12.4	11.9 ± .5
38	5	16.2	15.0 ± 1.3
39	5	15.1	12.9 ± 2.9
40	5	12.5	10.9 ± 1.9
41	5	11.5	10.2 ± 2.2
42	5	12.0	10.9 ± 1.3
43	5	12.7	11.1 ± 2.1
44	5	16.5	13.6 ± 2.6
45	5	12.1	9.9 ± 2.6
46	5	12.9	11.4 ± 1.3
47	5	12.1	11.0 ± 1.6
48	5	13.7	11.2 ± 3.3
49	5	14.4	11.2 ± 3.4
50	4	11.2	10.1 ± 2.1
51	5	12.3	10.4 ± 1.5
52	5	11.9	11.0 ± 1.6
53	4	13.1	10.7 ± 3.3
54	5	15.5	12.5 ± 3.1
55	5	12.4	11.8 ± 1.2
56	5	12.3	10.8 ± 1.3
57	5	10.6	9.1 ± 2.0
58	5	13.3	10.7 ± 2.2

[a] Average and 95-percent confidence limits for the average.

Water monitoring

The water monitoring program is designed to provide for surveillance of the Los Alamos municipal water supply, which is drawn from the deep aquifer underlying the laboratory area, as well as for general surveillance of the ground and surface waters in the vicinity (figure 3).

Water samples are collected in new polyethylene bottles. For samples from wells other than supply wells, a sufficient quantity of water is drawn and discarded so that the sample is representative of the ground water at the time of sampling. Samples from supply wells are collected at the individual well heads during pumping. Samples of surface water are bailed from a convenient pool or allowed to flow directly into the sample container. All samples are analyzed by radiochemical methods for

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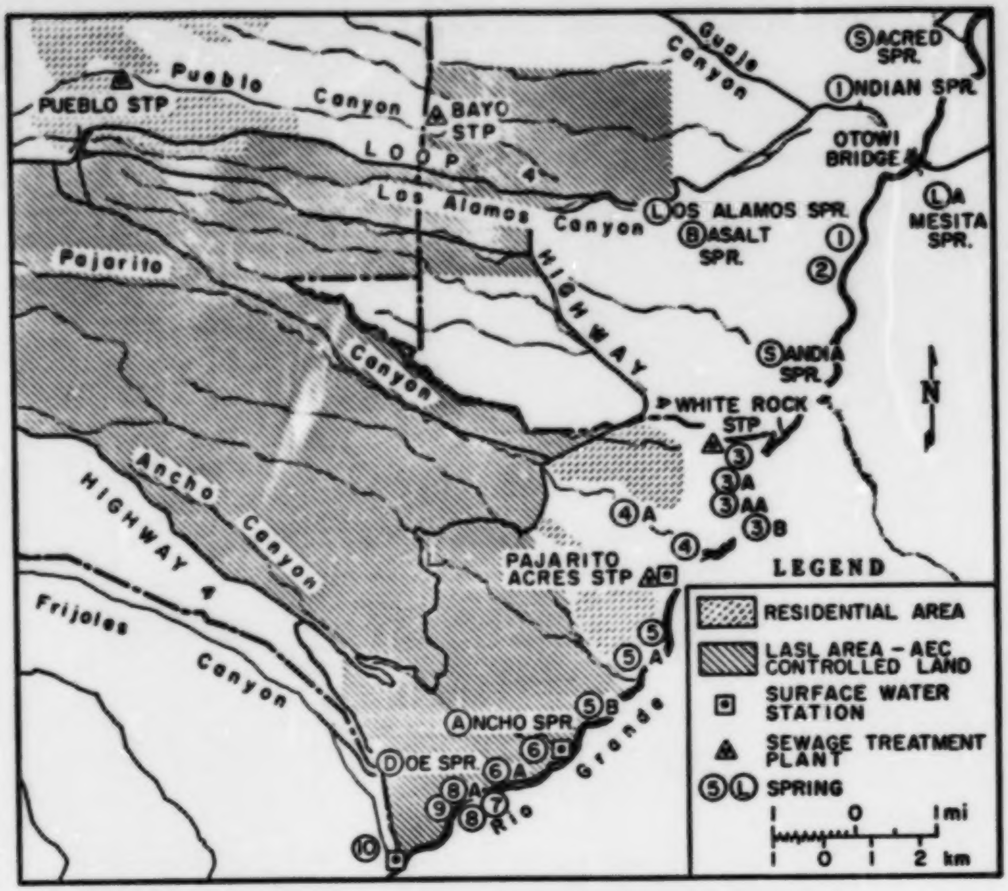
Puebla
PUEBLO STP
Canyon
BAYO STP
LOOP 4
Los Alamos Canyon
Guaje Canyon
SACRED SPR.
INDIAN SPR.
OTOWI BRIDGE
LA MESITA SPR.
LOS ALAMOS SPR.
BASALT SPR.
1
2
Pajarito Canyon
HIGHWAY
SANDIA SPR.
N
WHITE ROCK STP
3
3A
3AA
3B
4A
4
PAJARITO ACRES STP
LEGEND
RESIDENTIAL AREA
LASL AREA - AEC CONTROLLED LAND
SURFACE WATER STATION
SEWAGE TREATMENT PLANT
5 L SPRING
1 0 1 mi
1 0 1 2 km
Ancho Canyon
HIGHWAY 4
Frijoles Canyon
5
5A
5B
ANCHO SPR.
6
6A
DOE SPR.
8A
9
8
7
10
Rio Grande

Figure 3. Locations of surveillance water sampling stations, Los Alamos

gross alpha, beta, and gamma emitters; tritium, plutonium-238, plutonium-239 and cesium-137. An analyses for radium or strontium are performed if such analyses are indicated by the gross alpha or gross beta measurements. A fluorometric technique is used to measure the concentration of uranium.

The plutonium determinations performed on these water samples deserve special mention since tenuous identifications of trace amounts of this material were made on several occasions. These identifications are believed to be due to cross-contamination in the analytical laboratory or to fluctuations of the MDL, both very real problems at the low concentrations being investigated here. Thus, those samples in which traces of plutonium were found are reported with the understanding that they probably are not indicative of actual plutonium contamination of the water from which they were taken. Verification will depend upon patterns established by analyses of future sample collections.

Los Alamos water supply

Samples of water were collected and analyzed in a continuing program to monitor the chemical and radiochemical quality of the municipal water supply at Los Alamos. This water is pumped from the 16 deep supply wells completed into the main aquifer and ranging in

Table 9. Analyses of Los Alamos water system samples, January-December 1971

Determination	Units	Number of samples	Range			Detection limit
			Maximum	Minimum	Average	
January-June 1971:						
Gross alpha	pCi /liter	18	15	<2.0	2.0	2.0
Gross beta	pCi /liter	18	7.2	<2.0	3.0	2.0
Plutonium-238	fCi /liter	18	<50	<50	<50	50
Plutonium-239	fCi /liter	18	<50	<50	<50	50
Tritium	nCi /liter	18	<1.0	<1.0	<1.0	1.0
Total uranium	µg /liter	18	9.1	<.40	1.5	.40
July-December 1971:						
Gross alpha	pCi /liter	17	4.0	<1.0	<1.3	1.0
Gross beta	pCi /liter	17	<1.0	<1.0	<1.0	1.0
Plutonium-238	fCi /liter	17	<50	<50	<50	50
Plutonium-239	fCi /liter	17	<50	<50	<50	50
Cesium-137	nCi /liter	17	<.35	<.35	<.35	.35
Tritium	nCi /liter	17	<1.0	<1.0	<1.0	1.0
Total uranium	µg /liter	17	2.7	<.40	<.77	.40

Table 10. Analysis of water from regional sampling stations January-December 1971

Determination	Units	Number of samples	Range			Galisteo Reservoir	Detection limit
			Maximum	Minimum	Average		
January-June 1971:							
Gross alpha	pCi /liter	15	2.8	<2.0	2.0	<2.0	2.0
Gross beta	pCi /liter	15	12	<2.0	4.3	7.0	2.0
Plutonium-238	fCi /liter	15	<50	<50	<50	<50	50
Plutonium-239	fCi /liter	15	<50	<50	<50	<50	50
Tritium	nCi /liter	15	<1.0	<1.0	<1.0	<1.0	1.0
Total uranium	µg /liter	15	2.7	<.40	1.1	6.8	.40
July-December 1971:							
Gross alpha	pCi /liter	16	6.0	<1.0	<1.6		1.0
Gross beta	pCi /liter	16	6.0	<1.0	<3.1		1.0
Plutonium-238	fCi /liter	16	<50	<50	<50		50
Plutonium-239	fCi /liter	16	60	<50	<51		50
Cesium-137	nCi /liter	16	<.35	<.35	<.35		.35
Tritium	nCi /liter	16	<1.0	<1.0	<1.0		1.0
Total uranium	µg /liter	16	9.5	<.40	2.5		.40

depth from 870 to 2,600 feet. One spring on the eastern flanks of the Jemez Mountains has been developed and also contributes to the water supply. About 5 billion gallons of water were supplied to the Los Alamos complex during 1971. Additional data were obtained from two test wells which also are completed into the main aquifer. The range and average of constituents in the water from the 16 supply wells and the 2 test wells are shown in table 9.

These results indicate no significant change in the water quality during this reporting period as compared to previous analyses. The maximum concentrations were all well below the limits defined by the U.S. Public Health Service standards for drinking water (4) and the concentration guides for radioactive materials as given in AEC Manual Chapter 0524.

Regional surface water

Offsite rivers and reservoirs in and adjacent to the Los Alamos areas are sampled and analyzed on a routine basis to provide information on general water quality in the area and to serve as background for other measurements. During this period, 8 water samples were collected from 4 rivers, the Rio Chama at Chamita and the Rio Grande at Embudo, Otowi and Cochiti. In addition, 8 samples were taken from the following bodies of water: the Caliente River, Santa Cruz Reservoir, Galisteo Reservoir, the Rio Grande at Bernalillo, Jemez Reservoir, Jemez Creek, Fenton Lake, and Abiquiu Reservoir. The range and average of constituents of water from these sampling stations is shown in table 10. It should be noted that the quantity of water from those sources is subject to drastic fluctuations due to variations in discharge and in size and terrain of the drainage area. The analysis of the water taken from the Rio Grande at Embudo indicated a trace of plutonium-239.

General water surveillance

Samples of sewage, effluent, surface water, shallow ground water and water from nearby reservoirs used for irrigation were collected and analyzed to help assess the overall impact of the laboratory operations on the environment.

The range and average of constituents in sewage effluent from four offsite municipal sewage treatment ponds and lagoons is shown in table 11. The positive value of 70 fCi/liter for plutonium-239 was detected in the sample from the Pueblo Treatment Plant. This is a very low value and is probably due to contamination in the handling of the sample prior to or during analysis. Trace amounts of plutonium-238 were reported in one sample each from the Rock Sewage Treatment Plant and the Bayo Sewage Treatment Plant, 60 and 80 fCi/liter, respectively.

The range and average of the measurements on water samples from four streams, two reservoirs, two springs, and two observation holes are given in table 12 for January–June 1971. The results of the measurements on water samples indicate no anomalies. The observation holes are shallow penetrations into the alluvium underlying the canyons and the samples represent water which has seeped into the alluvium and is essentially static. Three of the intermittent flow stations and one observation hole are onsite.

Table 11. Analysis of effluents from sewage treatment plants, January-December 1971

Determination	Units	Number of samples	Range			Detection limit
			Maximum	Minimum	Average	
January-June 1971:						
Gross alpha	pCi/liter	4	<2.0	<2.0	<2.0	2.0
Gross beta	pCi/liter	4	40	12	27	2.0
Plutonium-238	fCi/liter	4	<50	<50	<50	50
Plutonium-239	fCi/liter	4	70	<50	60	50
Tritium	nCi/liter	4	<1.0	<1.0	<1.0	1.0
Total uranium	μg/liter	4	2.0	.60	.90	.40
July-December 1971:						
Gross alpha	pCi/liter	8	2	<1.0	<1.0	1.0
Gross beta	pCi/liter	8	37	2	12	1.0
Plutonium-238	fCi/liter	8	80	<50	<55	50
Plutonium-239	fCi/liter	8	<50	<50	<50	50
Cesium-137	nCi/liter	4	<.35	<.35	<.35	.35
Tritium	nCi/liter	8	13	<1.0	<2.5	1.0
Total uranium	μg/liter	8	<1.8	<.40	<1.1	.40

Table 12. Analysis of water from stream, reservoir, spring and observation hole surveillance stations, January-June 1971

Constituent	Units	Number of samples	Range			Detection limit
			Maximum	Minimum	Average	
Offsite stations:						
Gross alpha	pCi/liter	6	2.4	<2.0	2.0	2.0
Gross beta	pCi/liter	6	2.3	<2.0	2.1	2.0
Plutonium-238	fCi/liter	6	<50	<50	<50	50
Plutonium-239	fCi/liter	6	<50	<50	<50	50
Tritium	nCi/liter	6	<1.0	<1.0	<1.0	1.0
Total uranium	μg/liter	6	1.4	<.40	.70	.40

Table 13. Analyses of offsite ground water, July-December 1971

Determination	Unit	Los Alamos Spring	Basalt Spring	Detection level
Gross alpha	pCi/liter	<1.0	<1.0	1.0
Gross beta	pCi/liter	<1.0	<1.0	1.0
Plutonium-238	fCi/liter	<50	<50	50
Plutonium-239	fCi/liter	<50	<50	50
Cesium-137	nCi/liter	<.35	<.35	.35
Tritium	nCi/liter	<1.0	<1.0	1.0
Total uranium	µg/liter	.60	1.8	.40

Table 14. Analysis of offsite surface and ground water from the White Rock Canyon, July-December 1971

Determination	Unit	Number of samples	Range			Detection limit
			Maximum	Minimum	Average	
Gross alpha	pCi/liter	19	6.0	<1.0	<1.5	1.0
Gross beta	pCi/liter	19	2.5	<1.0	<1.1	1.0
Plutonium-238	fCi/liter	19	70	<50	<51	50
Plutonium-239	fCi/liter	19	50	<50	<50	50
Cesium-137	nCi/liter	19	<.35	<.35	<.35	.35
Tritium	nCi/liter	19	<1.0	<1.0	<1.0	1.0
Total uranium	µg/liter	19	13.0	<.40	<1.8	.40

Samples from two surveillance surface and ground water stations—(Los Alamos Spring and Basalt Spring) are collected semiannually. The results of the analyses of these samples are given in table 13 for July–December 1971. No results were abnormal for these stations.

A group of samples collected only on a biennial basis consists of water samples collected from 24 spring and 3 stream stations in the White Rock Canyon of the Rio Grande. These springs and streams are perennial with most of the water discharging from the main aquifer from which the municipal water supply is drawn.

The range and average of constituents in water from offsite stations at 17 springs and 2 streams in the White Rock Canyon are shown in table 14 for July–December 1971. Spring 3, a highly mineralized spring issuing from a fault line on the east bank of the river, is responsible for several of the reported maximum values. Its natural uranium concentrations are much higher than in water from the other stations. Spring 1 is a seep area more than an acre in extent, and the sample was collected near its discharge into the river. Traces of plutonium-238 and plutonium-239 were found for the first time in water from this source.

Sediments

Sediments are those earthen materials which have been transported and reworked by surface water. Samples are collected at the 40-50 km distant stations from which regional surface water samples were obtained. In addition, samples are taken for general surveillance from stream beds in the canyons in the vicinity of the laboratory. Some of these streams occur naturally and may flow perennially or intermittently during the rainy season. Some are streams produced by effluents from laboratory or municipal facilities.

Sediment samples from perennial streams are taken from dunes built up in eddies behind boulders in the main channel. In still water, the samples are dredged from the bottom with a bailer at some convenient point. From the intermittent streams, the samples are collected across the main channel to a 1-inch depth with a 3-inch scoop. The samples are placed in unused polyethylene containers for storage and transport to the laboratory. The samples are leached with acids and determinations of gross alpha emitters, gross beta emitters, plutonium and uranium are made on the acid leach. Strontium analyses are performed if the gross beta activity is high.

Table 15. Analyses of regional sediment samples, January-December 1971

Determination	Unit	Number of samples	Range			Detection limit
			Maximum	Minimum	Average	
January-June 1971:						
Gross alpha	pCi/g	9	8.6	1.1	3.4	1.0
Gross beta	pCi/g	9	6.7	1.1	3.5	1.0
Plutonium-238	fCi/g	9	3.0	<1.0	1.7	1.0
Plutonium-239	fCi/g	9	5.0	1.0	3.1	1.0
Total uranium	ng/g	9	130	<10	52	10
July-December 1971:						
Gross alpha	pCi/g	8	5.0	2.0	3.0	1.0
Gross beta	pCi/g	8	3.0	1.0	2.0	1.0
Plutonium-238	fCi/g	8	3.0	1.0	2.6	1.0
Plutonium-239	fCi/g	8	4.0	2.0	2.0	1.0
Cesium-137	fCi/g	8	200	200	200	200
Total uranium	ng/g	8	310	70	190	10

Sediments were collected and analyzed from the regional surface water sampling stations to provide general data on the quantities of radioactive materials in the environment beyond the general laboratory area. The results of the analyses are given in table 15.

Sediments for general surveillance

The results of the analyses of onsite and offsite samples are given in table 16. In general, the results for these sediment samples appear to be about as expected. Concentrations of plutonium lie in the range expected from fallout with the exception of the five samples taken from Pueblo, Los Alamos, and Mortandad Canyons.

The area from which the two Pueblo Canyon samples were taken is known to have trace amounts of plutonium as a result of earlier releases of industrial effluents into Acid Canyon, a tributary to Pueblo Canyon, a short distance above these sampling points. These effluents were released from 1949 through 1962, and the treatment plant has since been dismantled. The results of this program are in agreement with and confirm values reported earlier for this region (*5*).

The two positive Los Alamos Canyon samples also were from an area known to contain small quantities of this material washed down the canyon from effluent disposal operations in DP Canyon, which is tributary to Los Alamos Canyon several miles upgrade. The concentrations measured essentially are the same as those reported earlier (*5*).

The positive Mortandad Canyon sample reflects operations at the central liquid waste treatment plant at TA-50, which discharges liquid effluent into Effluent Canyon, a tributary to Mortandad Canyon, a short distance upstream of the sample collection station. Again, the values reported here agree with those reported earlier (*5*).

One onsite sample exhibited an unusually high uranium concentration, reflecting the fact that it was collected in an area where explosive tests had dispersed uranium.

Soils

Soils are those earthen materials that are weathered in place. They are sampled primarily to indicate the possibility of deposition of contaminants from the atmosphere. Samples are collected by taking five plugs, 3 inches in diameter and 2 inches deep, at the corners and center of a square 10 meters on a side. The five plugs are composited into a single sample and analyzed for gross alpha and beta radioactivity, plutonium, cesium, tritium, and uranium, using basically the same techniques as for sediment samples. Samples are taken at the regional surface water stations and at stations established for general surveillance in the vicinity of Los Alamos.

A summary of the results from the samples taken at distances of 40 to 50 km from the center of the laboratory area is given in table 17. The values are in line with those expected from natural radioactivity and fallout from past weapons tests (*6*).

Table 16. Analysis of sediments collected for general surveillance January-December 1971

Sample determination	Units	Number of samples	Range			Detection limit
			Maximum	Minimum	Average	
January-June 1971:						
Offsite stations:						
Gross alpha	pCi/g	5	7.4	1.2	3.2	1.0
Gross beta	pCi/g	5	3.7	1.9	2.6	1.0
Plutonium-238	fCi/g	5	16	1.0	4.8	1.0
Plutonium-239	fCi/g	[a] 4	9.0	2.0	4.8	1.0
Total uranium	ng/g	5	190	70	130	10
Onsite stations:						
Gross alpha	pCi/g	7	6.3	1.1	2.5	1.0
Gross beta	pCi/g	7	31	<1.0	5.9	1.0
Plutonium-238	fCi/g	[b] 6	7.0	<1.0	4.3	1.0
Plutonium-239	fCi/g	[c] 3	6.0	<1.0	2.6	1.0
Total uranium	ng/g	5	810	70	250	10
July-December 1971:						
Offsite stations:						
Gross alpha	pCi/g	4	5.0	2.0	3.0	1.0
Gross beta	pCi/g	4	18.0	1.0	6.0	1.0
Plutonium-238	fCi/g	4	1.0	<1.0	<1.0	1.0
Plutonium-239	fCi/g	4	4.0	1.0	4.0	1.0
Cesium-137	fCi/g	4	<200	<200	<200	200
Total uranium	ng/g	4	80	20	50	10
Onsite stations:						
Gross alpha	pCi/g	2	11	5.0	8.0	1.0
Gross beta	pCi/g	2	8.0	4.0	6.0	1.0
Plutonium-238	fCi/g	2	5.0	<1.0	<3.0	1.0
Plutonium-239	fCi/g	2	7.0	1.0	4.0	1.0
Cesium-137	fCi/g	2	<200	<200	<200	200
Total uranium	ng/g	2	2,790	150	1,470	10

[a] Does not include one sample from Pueblo Canyon which gave 2.9 pCi/g.

[b] Does not include one sample from Mortandad Canyon which gave 1.6 pCi/g.

[c] Does not include one sample from Pueblo Canyon which gave 0.8 pCi/g, two samples from Los Alamos Canyon which gave 1.0 and 0.1 pCi/g, and one sample from Mortandad Canyon which gave 1.1 pCi/g.

A summary of the results from the samples taken in the vicinity of Los Alamos County is given in table 18.

The values found are again in general agreement with those expected from natural activity and fallout from past weapons tests with the exception of two samples. These two samples, which were high in plutonium, were taken from areas known to be contaminated from airborne effluents.

Discussion

The results of the monitoring program for this period confirm the generally low radiation levels in the Los Alamos environs as noted in previous periods. Measurements of the gross activities in air and precipitation indicate concentrations similar to those measured at other locations in the northern hemisphere where activity is entirely attributable to the presence of worldwide fallout. Isotopic measurements of iodine, plutonium, and tritium in the atmosphere show that the iodine concentrations are below the detection limit; that there are places where the plutonium concentrations may be somewhat above that expected from past weapons testing; and that some of the offsite concentrations of tritium appear to be about twice that encountered at locations distant from the laboratory.

In the following discussion we will use the concept of "dose commitment", the total radiation dose received by an individual during his remaining lifetime due to operations during this report period. For radionuclides with long effective half-lives (physical and biological) the length of the remaining lifetime must be considered. This length has arbitrarily been set as 50 years for the purposes of this report. For an element with an effective half-life considerably less than 50 years, by far the greatest part of the dose is contributed during the first few years, so that the length of the accumulation period is unimportant so long as it is longer than several half-lives. We thus speak merely of a "dose commitment" rather than a "50-year dose commitment." Furthermore, for an element with an effective half-life very short com-

Table 17. Analysis of soils in vicinity of regional surface waters January-December 1971

Determination	Units	Number of samples	Range			Detection limit
			Maximum	Minimum	Average	
January-June 1971						
Gross alpha	pCi/g	10	6.3	<1.0	3.3	1.0
Gross beta	pCi/g	10	9.2	3.1	5.2	1.0
Plutonium-238	fCi/g	10	11	<1.0	2.7	1.0
Plutonium-239	fCi/g	10	25	3.0	10	1.0
Total uranium	ng/g	10	310	80	190	10
July December 1971						
Gross alpha	pCi/g	9	10	2.0	5.0	1.0
Gross beta	pCi/g	9	10	4.0	6.0	1.0
Plutonium-238	fCi/g	9	5.0	1.0	3.0	1.0
Plutonium-239	fCi/g	9	20	3.0	10	1.0
Cesium-137	fCi/g	9	300	<200	<200	200
Tritium[a]	nCi/liter	9	9.0	<2.0	<4.0	2.0
Total uranium	ng/g	9	500	40	230	10

[a] Soil moisture distilled from sample.

Table 18. Analysis of soils taken for general surveillance, January-December 1971

Determination	Units	Number of samples	Range			Detection limit
			Maximum	Minimum	Average	
January-June 1971						
Offsite stations:						
Gross alpha	pCi/g	4	4.6	3.9	4.1	1.0
Gross beta	pCi/g	4	5.7	4.8	5.1	1.0
Plutonium-238	fCi/g	4	2.0	<1.0	1.5	1.0
Plutonium-239	fCi/g	4	15	7.0	12	1.0
Total uranium	ng/g	4	490	339	380	10
Onsite stations:						
Gross alpha	pCi/g	4	5.0	2.8	3.8	1.0
Gross beta	pCi/g	4	7.0	4.5	5.6	1.0
Plutonium-238	fCi/g	4	3.0	<1.0	1.8	1.0
Plutonium-239	fCi/g	[a] 2	18	12	15	1.0
Total uranium	ng/g	3	840	660	770	10
July-December 1971						
Offsite stations:						
Gross alpha	pCi/g	3	8.0	6.0	7.0	1.0
Gross beta	pCi/g	3	6.0	5.0	6.0	1.0
Plutonium-238	fCi/g	3	5.0	2.0	4.0	1.0
Plutonium-239	fCi/g	3	36	7.0	19	1.0
Cesium-137	fCi/g	3	<200	<200	<200	200
Tritium[b]	nCi/liter	3	14	13	3	2.0
Total uranium	ng/g	3	330	220	260	10
Onsite stations:						
Gross alpha	pCi/g	2	6.0	6.0	6.0	1.0
Gross beta	pCi/g	2	7.0	6.0	6.0	1.0
Plutonium-238	fCi/g	2	10	1.0	5.0	1.0
Plutonium-239	fCi/g	2	25	20	22	1.0
Cesium-137	fCi/g	2	<200	<200	<200	200
Tritium[b]	nCi/liter	2	15	14	14	2.0
Total uranium	ng/g	2	500	200	350	10

[a] Does not include one sample from TA-21 which gave 220 fCi/g and one from near TA-50 which gave 110 fCi/g.
[b] Soil moisture distilled from soil sample.

pared to 50 years, the dose is received substantially instantaneously, and it is sufficient to use the more familiar concept of dose rather than dose commitment.

Using the constants listed in the 1959 ICRP internal dose report (*7*), the highest offsite plutonium-238 concentration was sufficient to produce, during the report period, a dose commitment for the lungs of about 0.06 mrem assuming all of the material to be insoluble. Alternately, assuming all of the material to be soluble (20 percent transferred to bone, a quality factor of 10 and a "non-uniform distribution factor" of 5), the 50-year dose commitment to bone was about 1.9 mrem. The actual dose commitment would lie somewhere between these two. In comparison, the guide value from AEC Manual Chapter 0524 for the dose commitment for bone or lungs is 1,500 mrem for an individual or 500 mrem for a suitable sample of the population. The plutonium-239 results show no significant difference between stations indicating that the source is probably worldwide fallout. This source (averaged over all offsite stations) contributed an estimated dose commitment of about 0.09 mrem to the lungs or 3.4 mrem to bone.

During the reporting period, the average offsite tritium concentration in the Los Alamos area was sufficient to produce a whole body dose of about 0.22 mrem, using the quality factor of 1.7, used in the derivation of the 1960 ICRP-NCRP maximum permissible concentrations that apparently served as the basis for the AEC Manual Chapter 0524 concentration guides. If the quality factor of 1.0 now accepted by the ICRP and NCRP is used for these low energy beta radiations, this dose is about 0.13 mrem. This may be compared with the radiation protection guide for annual dose to the whole body given in AEC Manual Chapter 0524 of 500 mrem for an individual or 170 mrem for a suitable sample of the population.

External gamma and x-radiation levels, as measured by thermoluminescent dosimeters, were comparable to those measured elsewhere at approximately the same elevation. This suggests that the predominant contribution to external dose is from solar radiation.

The Los Alamos water supply remained uninfluenced by laboratory operations. Traces of plutonium have been tenuously identified in offsite samples collected from bodies of surface water, sewage effluent, and, in one instance, ground water. These identifications are believed to be due to cross-contamination in the laboratory, a very real problem when dealing with such low levels.

Small quantities of plutonium and some beta emitters were found in sediment collected in several of the offsite canyons, resulting from past disposal operations. These locations, while accessible to the public, are reasonably isolated so that occupancy is limited to an occasional hiker or hunter. It is impossible to estimate a possible dose or dose commitment from these deposits; the low occupancy factor and the association of the material with large quantities of sediment should preclude the uptake of any significant quantities by people, animals, or plants.

Summary

Results of the environmental monitoring program at the Los Alamos Scientific Laboratory for January through December 1971 are given. The program is in the process of change in order to better satisfy the needs for environmental data at very low levels. Results for this period indicate no significant changes from those for previous periods. Concentrations of plutonium-238 above that expected from worldwide fallout were measured at several stations including one offsite station. The 50-year dose commitment resulting from 6 months exposure at this station is estimated to be less than 0.04 mrem for the lungs or 2 mrem for the bone as compared to the annual radiation protection guide value given in AEC Manual Chapter 0524 of 1,500 mrem for an individual or 500 mrem for a suitable sample of the population. Tritium concentrations in the atmosphere appear to be elevated in the Los Alamos area and may have contributed a whole-body dose of about 0.1 mrem during the report period as compared to the annual guide value of 500 mrem for an individual or 170 mrem for a suitable sample of the population.

Areas with trace contamination by plutonium and beta emitters are present in canyons now used or previously used for disposal of liquid effluents. These are unoccupied areas and present no problems in terms of radiation exposure. Small quantities of plutonium also appear in the soils around the plutonium fabrication facility (TA-21) as a result of past deposition from airborne effluents. Again, the quantities are small and there is no indication of an ele-

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vated air concentration which is the hazard of concern since inhalation is believed to be the main route of plutonium entry into the body.

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Reported Nuclear Detonations, October 1973

(Includes seismic signals presumably from foreign nuclear detonations)

The U.S. Atomic Energy Commission conducted an underground nuclear test at its Nevada Test Site on October 12, 1973. The test was in the low yield range of less than 20 kilotons.

Seismic signals, presumably from a Soviet underground nuclear explosion, were recorded by the United States on October 26, 1973. The signals originated at approximately 12 a.m. EDT, at the Semipalatinsk nuclear test area and were equivalent to those of an underground nuclear explosion in the yield range of 20–200 kilotons.

Seismic signals presumably from a Soviet underground nuclear test in the yield range of less than 20 kilotons were recorded by the United States on October 26, 1973 at about 2:00 a.m. EDT. The signals originated in the southern Ural area of the Soviet Union.

Seismic signals from a large Soviet underground nuclear test were recorded by the United States on October 27, 1973. The signals originated at approximately 3 a.m. EDT, in southern Novaya Zemlya in the Arctic. This test was about the same size as the one on September 12, 1973, which was announced as 3 to 6 megatons.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U.S. nuclear detonations may be obtained upon request from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

EVALUATION OF URANIUM MINE ATMOSPHERES BY MEASUREMENTS OF THE WORKING LEVEL AND RADON. *Duncan A. Holaday* and *James H. Jones. Radiation Data and Reports, Vol. 14, November 1973*, pp. 653–657.

Using estimates of equilibrium ratios and concentrations of unattached atoms in uranium mines, calculations were performed and results presented of the amount of alpha energy per liter of air per working level available to be imparted to the various regions of the respiratory tract. It was discovered that the factor that caused the greatest effect on the alpha energy that could be deposited in the lungs was a change in the unattached fraction of the radon daughters. If the radon concentration was used to determine potential exposure, radon to daughter ratios also had a marked effect on the potential alpha energy deposition.

KEYWORDS: Alpha energy deposition, mines, radon, radon daughters, uranium.

RADIOLOGICAL SURVEY OF NEW LONDON HARBOR, THAMES RIVER, CONN. AND ENVIRONS. *Sam T. Windham* and *Charles R. Phillips. Radiation Data and Reports, Vol. 14, November 1973*, pp. 659–666.

The Eastern Environmental Radiation Laboratory, in cooperation with the U.S. Naval Ship Systems Command, conducted a radiological survey of the New London Harbor, Thames River and environs to determine if nuclear ship activity in that area has contributed radioactivity which could contribute detectable radiation exposure to the public. Comparison with a similar survey conducted in 1966 show that activity levels in sediment have decreased by an average factor of 33 due to a reduction in the amount of radioactivity discharged, radioactive decay and natural sedimentation. Analysis of samples indicative of direct pathways for human exposure lead to the conclusion that no significant radiation exposure to the public has resulted from nuclear ship operations in this area. It is concluded that the environmental surveillance routinely conducted by the Navy should be adequate to assure protection of the public from the routine nuclear ship operations.

KEYWORDS: Connecticut, environmental radioactivity, harbor survey, nuclear ships.

RADIATION DATA AND REPORTS

Volume 14, Number 12, December 1973

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

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U.S. ENVIRONMENTAL PROTECTION AGENCY
Russell E. Train, Administrator

Reports

Vertical Distribution of Fallout Cesium-137 in Cultivated Soils[1]

Jerry C. Ritchie and J. Roger McHenry[2]

Fallout cesium-137 was found to be evenly distributed in the upper 15-20 cm of cultivated soils of five watersheds in the mid-United States. This distribution pattern is markedly different from the vertical distribution of cesium-137 in noncultivated soils.

Fallout cesium-137 has been shown to be concentrated in the upper few centimeters in untilled soil (*1–3*) and usually shows an exponential decrease with depth in the soil profile (*4–5*). Few studies (*6–7*) have dealt with the distribution of cesium-137 in cultivated soils. This study concentrated on the distribution of fallout cesium-137 in cultivated soils from five watersheds in the mid-United States.

Methods and materials

Two or more soil samples were collected in 5-cm increments to a depth of 25 to 30 cm in each watershed. Surface area of each sample was 500 cm^2. The samples were dried and sieved through a 12-mm screen. From 2,000 to 3,000 grams of the sample was put into Marinelli-type beakers, sealed and stored for a minimum of 4 weeks before counting. Gamma-ray spectrometric analyses were made using a 1,024-channel pulse height analyzer (*8*). The spectra were reduced to concentration values for cesium-137 using a least squares technique (*9*). The detection limit of the system for cesium-137 is approximately 0.1 pCi/g. Particle size analysis and cation exchange capacity were determined on all samples. No significant differences were found for particle size distribution or cation exchange capacity for samples taken from the same watershed.

Results and discussion

The vertical distribution of fallout cesium-137 is given for soils from five watersheds in four States (table 1). Cesium-137 is uniformly distributed in the upper 15 or 20 cm of the soil profiles, and decreases sharply below this depth. The Durant 1A watershed soil has a peak concentration of cesium-137 from the 5 to 15 cm depth. The distribution of cesium-137 in the upper 15 to 20 cm of cultivated soil would be due to the yearly mixing of these soils during tillage, since cesium-137 is tightly adsorbed to the finer soil particles and movement by natural chemical process is limited (*10*). The normal plow depth in these watersheds is 15 to 20 cm. Cline and Richard (*6*) and Walton (*9*) found a peak concentration of cesium-137 between the 10 to 20 cm depth, or at about the bottom of the plow layer. The uniform mixing in most of our samples would be caused by a continuing mixing of the soils by tillage operations over the period since fallout began.

The distribution of cesium-137 is markedly different in tilled soils as compared with nontilled soils (table 1). Differences in total concentration between tilled and nontilled soil in the watershed is due to erosional differences

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[1] Contribution of the USDA Sedimentation Laboratory, North Mississippi-Alabama Area, Agricultural Research Service, U.S. Department of Agriculture in cooperation with the University of Mississippi, the Mississippi Agricultural and Forestry Experiment Station, and the U.S. Atomic Energy Commission (Contract No. AT(49-7)-3029).

[2] Botanist and research chemist, Oxford, Miss. 38655.

Table 1. Vertical distribution of fallout cesium-137 in tilled and nontilled soils

Depth (cm)	Cesium-137 concentration (nCi/m^2)									
	Watershed									
	Smith [a]		Murphy [a]		Ashland [b]		Durant 1A [c]		Elm Creek [d]	
	Tilled	Non-tilled	Tilled	Non-tilled	Tilled	Non-tilled	Tilled	Non-tilled	Tilled	Non-tilled
0– 5	29.3	135.2	31.4	133.9	27.3	100.7	11.4	51.0	47.5	85.1
5–10	32.9	22.2	33.2	16.9	25.5	15.2	19.6	27.3	46.7	25.2
10–15	23.4		31.5		26.9		16.2		22.7	
15–20	10.1		20.3		27.3		12.6		6.7	
20–25	5.0		3.4		17.2		4.3			
25–30					4.0					

[a] Holly Springs, Miss.
[b] Ashland, Mo.
[c] Durant, Okla.
[d] Gainesville, Tex.

between sites. In the nontilled soils, the highest concentration is in the upper 5 cm, decreasing below this depth. In nontilled soils, the original depositional cesium-137 approaches a planar source at the surface of the soil and the distribution below this planar source decreases sharply. In cultivated soil, the original deposition of cesium-137 as a planar source is dispersed throughout the top 10 or 20 cm, or more, depending on the tillage practices used. Below this mechanically mixed layer, the cesium-137 distribution decreases sharply with depth as in nontilled soils.

These two distinct distribution patterns of cesium-137 in tilled and nontilled soils are important in understanding the movement of fallout cesium-137 in watershed ecosystems. Movement and redistribution of cesium-137 in a watershed will be influenced by this depth mixing of fallout. Models for the movement of cesium-137 in watershed ecosystems and for the movement of cesium-137 from the soil into plants should account for these two patterns.

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Technical Notes

Iodine-131 in Milk Samples, July 9, 1973 through August 23, 1973

Eric Geiger[1] *and Milton A. Trautman*[2]

Eberline Instrument Corporation, using a method similar to that specified in AEC Regulatory Guide 4.3, has, since June 1973, made high-sensitivity measurements of iodine-131 in milk samples on a routine basis. Using this method, measurements were made of unusual concentrations of iodine-131 in milk which we believe are attributable to debris from the atmospheric nuclear detonation in the People's Republic of China at about midnight, e.d.t. on June 26, 1973. The iodine-131 was widely dispersed throughout the midwestern part of the United States (table 1), and was first detected in milk collected on July 9, 1973. Maximum levels were reached during the following 2 weeks with measurable concentrations observed until the middle of August.

The presence of iodine-131 was confirmed by high resolution gamma spectrometry (using groups of samples) and by half-life studies. We did not detect iodine-131 in air samples (charcoal cartridges) or vegetation samples collected during the same period.

Table 1. Average concentration of iodine-131 in milk

Date collected (1973)	Concentration[a] (pCi/liter)		
	Eastern Nebraska	Eastern Iowa	Eastern Illinois
Prior to July 9		<0.5	<0.5
July 9		<.4 (3)	.6 (2)
July 10		.4 (2)	
July 11		.6 (6)	
July 12	0.9 (3)		
July 16			2.1 (2)
July 19	1.4 (3)		
July 23			.9 (2)
July 24		1.7 (8)	
July 26	1.9 (3)		
July 30			.7 (2)
July 31	.6 (3)		
Aug 6			.2 (2)
Aug 9	.2 (3)		
Aug 13		.8 (5)	
Aug 15			.3 (2)
Aug 16	.3 (3)		.3 (2)
Aug 20		.3 (5)	
Aug 23	.1 (3)		

[a] Blank spaces indicate that no samples were collected at that location on that date. Numbers in parentheses indicate number of dairies included in the average. Counting errors (2σ) ranged from 0.05 to 0.5 pCi/liter depending on counting time and chemical yield.

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[1] Eberline Instrument Corporation, Santa Fe, N. Mex.
[2] Eberline Instrument Corporation, West Chicago, Ill.

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SECTION I. MILK AND FOOD

Milk Surveillance, August 1973

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption readily can be obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 65 sampling stations: 63 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 16 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—7 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks reporting presently in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radio-

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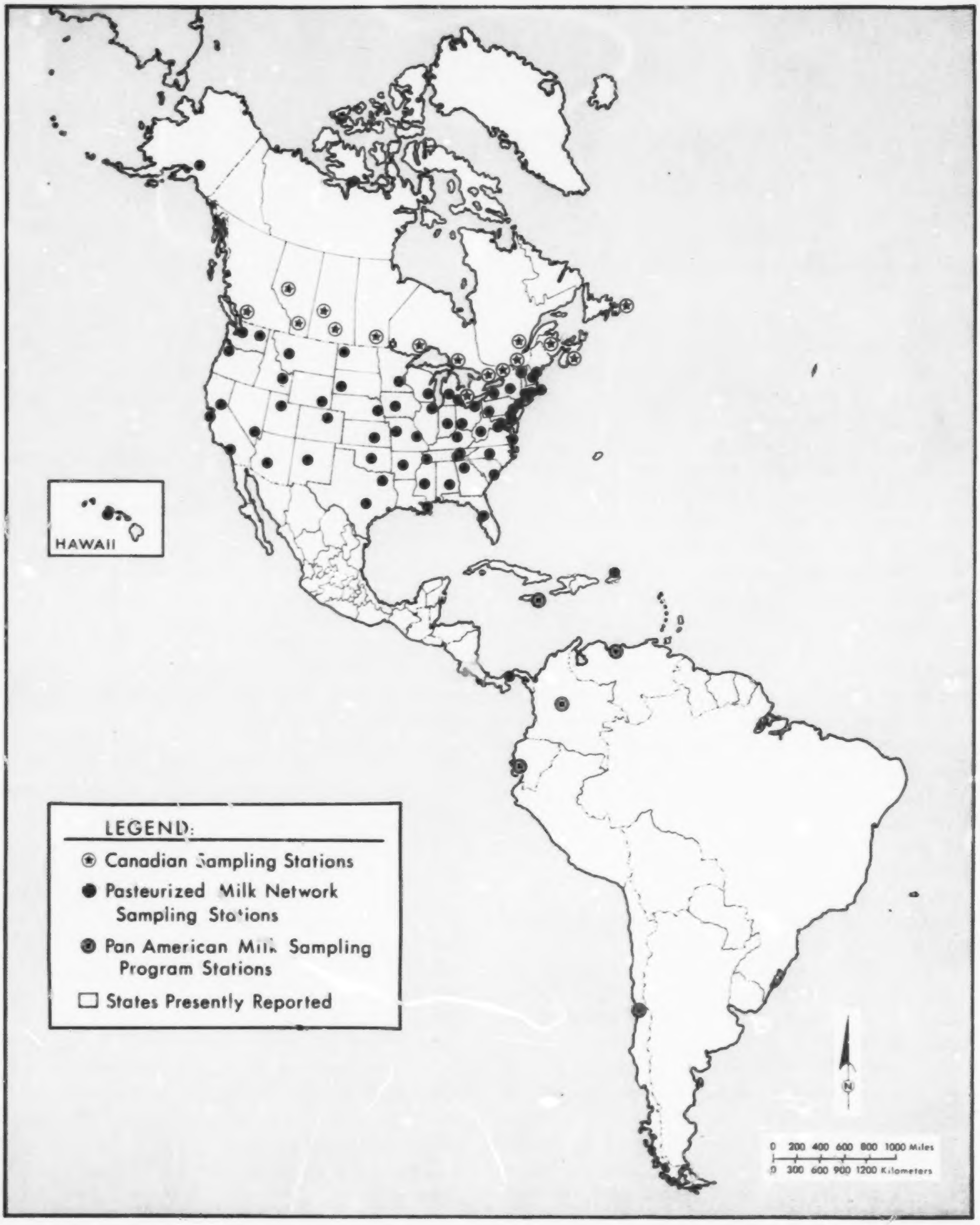
HAWAII
LEGEND:
Canadian Sampling Stations
Pasteurized Milk Network Sampling Stations
Pan American Milk Sampling Program Stations
States Presently Reported
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers
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Figure 1. Milk sampling networks in the Western Hemisphere

strontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been previously outlined (*4*).

The most recent study was conducted during June 1972 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 18 laboratories producing data for the network reports in *Radiation Data and Reports*, 14 participated in the study.

The accuracy results of this study for these 14 laboratories are shown in table 1. The accuracy of the cesium-137 measurements continues to be excellent as in previous experiments. However, both the accuracy and precision need to be improved for iodine-131, strontium-89, and strontium-90 which could probably be accomplished through recalibration.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration		Number of laboratories in each category				Experimental 2σ error (pCi/liter)
		Acceptable [a]	Warning level [b]	Unacceptable [c]	Total	
Iodine-131	(96 or 99 pCi/liter)	7 (58%)	1 (8%)	4 (33%)	12	6
	(438 or 484 pCi/liter)	11 (85%)	0	2 (15%)	13	25 or 28
Cesium-137	(53 or 54 pCi/liter)	11 (92%)	0	1 (8%)	12	6
	(295 or 303 pCi/liter)	11 (85%)	2 (15%)	0	13	17
Strontium-89	(29 or 30 pCi/liter)	9 (82%)	0	2 (18%)	11	6
	(197 or 201 pCi/liter)	3 (33%)	1 (11%)	5 (56%)	9	11 or 12
Strontium-90	(32.1 or 32.4 pCi/liter)	4 (33%)	4 (33%)	4 (33%)	12	1.9
	(150.5 or 151.2 pCi/liter)	6 (55%)	0	5 (45%)	11	8.7

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and generally is increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*6*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below those practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error of precision expressed as pCi/liter or percent in a given concentration range also has been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the United States data on radioactivity in milk in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the February 1973 issue of *Radiation Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are reported routinely in *Radiation Data and Reports.* The relationship between the PMN stations and the State stations is shown in figure 2. The first column in table 2 under each of the reported radionuclides gives the monthly average for the station and the num-

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Table 2. Concentrations of radionuclides in milk for August 1973 and 12-month period September 1972 through August 1973

Sampling location		Type of sample •	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:						
Ala:	Montgomery •	P	NA	5	0	5
Alaska:	Palmer •	P	NA	4	0	1
Ariz:	Phoenix •	P	NA	0	0	0
Ark:	Little Rock •	P	NA	10	0	2
Calif:	Los Angeles •	P	NA	0	0	0
	Sacramento •	P	NA	1	0	0
	San Francisco •	P	NA	0	0	0
	Del Norte	P	5	10	10	7
	Fresno	P	0	1	0	2
	Humboldt	P	0	3	0	1
	Los Angeles	P	0	1	0	1
	Mendocino	P	3	2	0	3
	Sacramento	P	0	2	0	3
	San Diego	P	0	1	0	2
	Santa Clara	P	0	2	0	2
	Shasta	P	0	2	0	3
	Sonoma	P	0	2	0	3
Colo:	Denver •	P	NA	2	0	0
	East	R	NS	NA	NS	14
	Northeast	R	NS	NA	NS	1
	Northwest	R	NS	NA	NS	0
	South Central	R	NS	NS	NS	NS
	Southeast	R	NS	NA	NS	0
	Southwest	R	NA	NA	[d]0	2
	West	R	NA	NA	[d]0	0
Conn:	Hartford •	P	NA	4	0	4
	Central	P	NA		NA	
Del:	Wilmington •	P	NA	6	0	3
D.C:	Washington •	P	NA	4	0	1
Fla:	Tampa •	P	NA	4	28	30
	Central	R	5	5	54	35
	North	R	6	6	15	12
	Northeast	R	7	6	47	32
	Southeast	R	5	5	38	44
	Tampa Bay area	P	4	5	24	30
	West	R	10	8	12	8
Ga:	Atlanta •	P	NA	6	0	7
Hawaii:	Honolulu •	P	NA	1	0	0
Idaho:	Idaho Falls •	P	NA	3	0	0
Ill:	Chicago •	P	NA	5	0	2
Ind:	Indianapolis •	P	NA	5	0	3
	Central	P	4	7	0	8
	Northeast	P	5	5	15	9
	Northwest	P	6	7	10	9
	Southeast	P	6	7	15	6
	Southwest	P	7	7	0	9
Iowa:	Des Moines •	P	NA	5	0	0
	Des Moines	P	4	5	0(3)	0
	Iowa City	P	5	5	0	0
	LeMars	P	4	4	0	2
	Little Cedar	P	6	7	0	1
Kans:	Wichita •	P	NA	5	0	0
	Coffeyville	P	9	8	0	9
	Dodge City	P	5	4	0	6
	Falls City, Nebr	R	NS	NS	NS	NS
	Hays	P	9	9	0	5
	Kansas City	P	4	8	0	9
	Topeka	P	8	7	0	4
	Wichita	P	6	8	10	11
Ky:	Louisville •	P	NA	5	0	1
La:	New Orleans •	P	NA	9	0	1
Maine:	Portland •	P	NA	6	18	19
Md:	Baltimore •	P	NA	6	0	6
Mass:	Boston •	P	NA	6	11	16
Mich:	Detroit •	P	NA	6	0	
	Grand Rapids •	P	NA	8	0	1
	Bay City	P	NS	7	NS	1
	Charlevoix	P	6	7	0	4
	Detroit	P	6	4	0	2
	Grand Rapids	P	11	8	0	1
	Lansing	P	9	6	0	5
	Marquette	P	13	9	14	10
	Monroe	P	9	6	0	1
	South Haven	P	8	7	0	4
Minn:	Minneapolis •	P	NA	7	0	4
	Bemidji	P	11	7	28	14
	Duluth	P	18	16	33	21
	Fergus Falls	P	7	6	0	0
	Little Falls	P	26	17	82	27
	Mankato	P	4	4	0	0
	Marshall	P	4	4	0	0

See footnotes at end of table.

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Table 2. Concentrations of radionuclides in milk for August 1973 and 12-month period September 1972 through August 1973—continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:						
Minn:	Minneapolis	P	9	5	0	0
	Rochester	P	8	7	0	0
Miss:	Jackson[c]	P	NA	8	0	7
Mo:	Kansas City[c]	P	NA	4	0	0
	St. Louis[c]	P	NA	6	0	1
Mont:	Helena[c]	P	NA	2	0	0
Nebr:	Omaha[c]	P	NA	3	0	0
Nev:	Las Vegas[c]	P	NA	3	0	0
N.H:	Manchester[c]	P	NA	7	0	10
N.J:	Trenton[c]	P	NA	6	0	5
N. Mex:	Albuquerque[c]	P	NA	0	0	2
N.Y:	Buffalo[c]	P	NA	4	0	3
	New York City[c]	P	NA	6	0	4
	Syracuse[c]	P	NA	6	0	2
	Albany	P	7	4	0	0
	Buffalo	P	5	4	0	0
	Massena	P	5	5	16	0
	New York City	P	7	7	16	0
	Syracuse	P	NS	5	NS	0
N.C:	Charlotte[c]	P	NA	7	0	6
N. Dak:	Minot[c]	P	NA	7	0	0
Ohio:	Cincinnati[c]	P	NA	5	0	2
	Cleveland[c]	P	NA	6	0	3
Okla:	Oklahoma City[c]	P	NA	3	0	0
Oreg:	Portland[c]	P	NA	4	0	1
	Baker	P	NA		NA	
	Coos Bay	P	NA		NA	
	Eugene	P	NA		NA	
	Medford	P	NA		NA	
	Portland composite	P	NA		NA	
	Portland local	P	NA		NA	
	Redmond	P	NA		NA	
	Tillamook	P	NA		NA	
Pa:	Philadelphia[c]	P	NA	5	0	2
	Pittsburgh[c]	P	NA	8	0	5
	Dauphin	P	6	4	0	1
	Erie	P	6	6	0	1
	Philadelphia	P	4	4	0	2
	Pittsburgh	P	8	6	0	1
R.I:	Providence[c]	P	NA	5	11	7
S.C:	Charleston[c]	P	NA	6	0	8
	Chapin	R	NS	8	NS	16
	Clemson	R	NS	7	NS	6
	Columbia	R	NS	7	NS	10
	Fairfield	R	NS	7	NS	16
	Hartsville-02	R	NS	6	NS	12
	Hartsville-03	R	16	17	13	15
	Lee County	R	NS	8	NS	17
	Oconee County	R	8	8	16	7
	Pickens	R	NS	7	NS	5
	Williston	R	NS	7	NS	14
	Winnsboro	R	NS	8	NS	16
S. Dak:	Rapid City[c]	P	NA	5	0	1
Tenn:	Chattanooga[c]	P	NA	6	0	4
	Knoxville[c]	P	NS		NS	
	Memphis[c]	P	NA	6	11	3
	Chattanooga	P	NA	8	0	5
	Clinton	R	NA	7	0 (2)	6
	Fayetteville	R	NA	7	0 (2)	5
	Kingston	R	NA	7	0 (2)	0
	Knoxville	P	NA	5	0	2
	Lawrenceburg	R	NS	6	NS	3
	Nashville	P	NS	6	NS	2
	Pulaski	R	NA	5	0	1
	Sequoyah	R	NS	8	NS	0
Tex:	Austin[c]	P	NA	0	0	0
	Dallas[c]	P	NA	4	0	0
	Amarillo	R	NA		NA	
	Corpus Christi	R	NA		NA	
	El Paso	R	NA		NA	
	Fort Worth	R	NA		NA	
	Harlingen	R	NA		NA	
	Houston	R	NA		NA	
	Lubbock	R	NA		NA	
	Midland	R	NA		NA	
	San Antonio	R	NA		NA	
	Texarkana	R	NA		NA	
	Uvalde	R	NA		NA	
	Wichita Falls	R	NA		NA	

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for August 1973 and 12-month period September 1972 through August 1973—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [c]	12-month average
UNITED STATES:						
Utah:	Salt Lake City [c]	P	NA	2	0	1
Vt:	Burlington [c]	P	NA	5	0	7
Va:	Norfolk [c]	P	NA	5	0	3
Wash:	Seattle [c]	P	NA	2	0	1
	Spokane [c]	P	NA	4	0	0
	Benton County	R	NS	1	NS	0
	Franklin County	R	0	1	0	0
	Longview	R	5	3	0	2
	Sandpoint, Idaho	R	5	5	0	1
	Skagit County	R	3	5	0	2
W. Va:	Charleston [c]	P	NA	6	0	3
Wisc:	Milwaukee [c]	P	NA	5	0	3
Wyo:	Laramie [c]	P	NA	1	0	1
CANADA:						
Alberta:	Calgary	P	NA		NS	
	Edmonton	P	NA		16	14
British Columbia:	Vancouver	P	NA		16	14
Manitoba:	Winnipeg	P	NA		NS	
New Brunswick:	Moncton	P	NA		5	9
Newfoundland:	St. John's	P	NA		30	22
Nova Scotia:	Halifax	P	NA		NS	
Ontario:	Ottawa	P	NA		3	6
	Sault Ste. Marie	P	NA		16	17
	Thunder Bay	P	NA		NS	
	Toronto	P	NA		7	7
	Windsor	P	NA		NS	
Quebec:	Montreal	P	NA		NS	
	Quebec	P	NA		NS	
Saskatchewan:	Regina	P	NA		NS	
	Saskatoon	P	NA		6	8
CENTRAL AND SOUTH AMERICA:						
Canal Zone:	Cristobal [c]	P	NS	0	NS	11
Chile:	Santiago	P	NS	1	NS	0
Colombia:	Bogota	P	5	1	0	0
Ecuador	Guayaquil	P	7	1	0	0
Jamaica:	Mandeville	P	NS	2	NS	42
Puerto Rico:	San Juan [c]	P	NA	1	0	2
Venezuela:	Caracas	P	2	1	0	2
PMN network average [e]			NA	4	1	3

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a month period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] The practical reporting level for this network differs from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:
Cesium-137: Colorado—25 pCi/liter; Oregon—15 pCi/liter.

[e] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

ber of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

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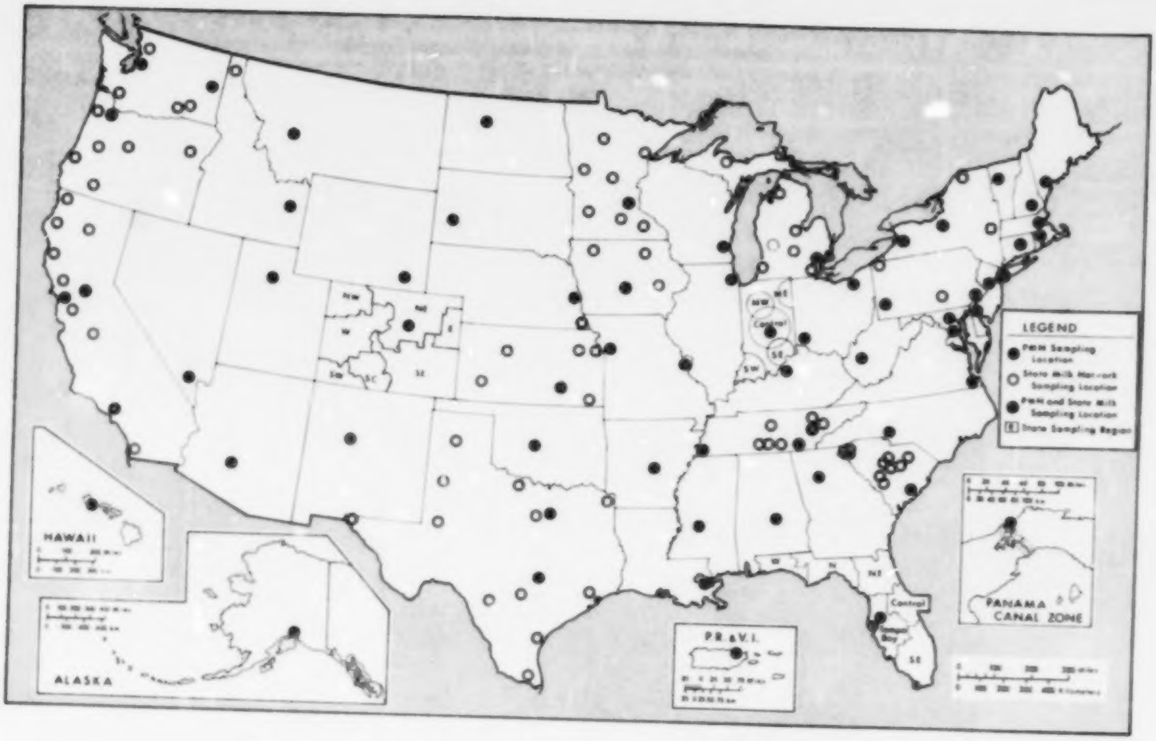

Figure 2. State and PMN milk sampling stations in the United States

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for August 1973 and the 12-month period, September 1972 to August 1973. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89 and iodine-131 data have been omitted from table 2 since levels at all of the stations for August 1973 were below the respective practical reporting levels.

Barium-140 results for individual samples were all below the practical reporting level with the following exception: Kans., Coffeyville (State) 11 pCi/liter.

Strontium-90 monthly averages ranged from 0 to 26 pCi/liter in the United States for August 1973 and the highest 12-month average was 17 pCi/liter (Little Falls, Minn., Hartsville–03, S.C.) representing 8.5 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 82 pCi/liter in the United States for August 1973, and the highest 12-month average was 44 pCi/liter (Southeast Florida) representing 1.2 percent of the value derived from the recommendations given in the Federal Radiation Council report.

The Office of Radiation Programs is in the process of modifying the milk program to make it more responsive to potential sources of environmental radioactivity. These changes will be reflected in future articles.

Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data from their milk surveillance networks:

Radiologic Health Section
Environmental Control Component
California Department of Health

Radiation Protection Division
Canadian Department of National
Health and Welfare

Radiological Health Section
Division of Occupational and
Radiological Health
Colorado Department of Health

Laboratory Division
Connecticut Department of Health

Radiological and Occupational
Health Section
Department of Health and
Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of
Environmental Conservation

Environmental Radiation Surveillance
Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Division of Radiological Health
South Carolina State Board of Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of
Social and Health Services

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(*1*) CAMPBELL, J. E., G. K. MURTHY, A. S. GOLDIN, H. B. ROBINSON, C. P. STRAUB, F. J. WEBER, and K. H. LEWIS. The occurrence of strontium-90, iodine-131, and other radionuclides in milk, May 1957 through April 1958. Amer J Pub Health 49:225 (February 1969).

(*2*) U.S. ATOMIC ENERGY COMMISSION, DIVISION OF ISOTOPES DEVELOPMENT. Chart of the Nuclides, Tenth Edition revised to December 1968. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*3*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk surveillance. Radiol Health Data Rep 9:730–746 (December 1968).

(*4*) ROSENSTEIN, M. and A. S. GOLDIN. Statistical technics for quality control of environmental radioassay. Health Lab Sci 2:93 (April 1965).

(*5*) BARATTA, E. J. and F. E. KNOWLES, JR. Interlaboratory study of iodine-131, cesium-137, strontium-89, and strontium-90 measurements in milk, June 1972, Technical experiment 72 MKAQ–1. Analytical Quality Control Service, Office of Radiation Programs, EPA, Washington, D.C. 20460 (December 1972).

(*6*) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).

Milk Surveillance Network, August 1973

National Environmental Research Center-Les Vegas, Environmental Protection Agency

The Milk Surveillance Network,[1] operated by the National Environmental Research Center-Las Vegas (NERC-LV) consists of 24 routine and 2 alternate sampling locations (figure 1) situated in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing sponsored by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site.

In the event of a release of radioactivity from the NTS, special sampling within the affected

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[1] This network is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. AEC, Las Vegas, Nev.

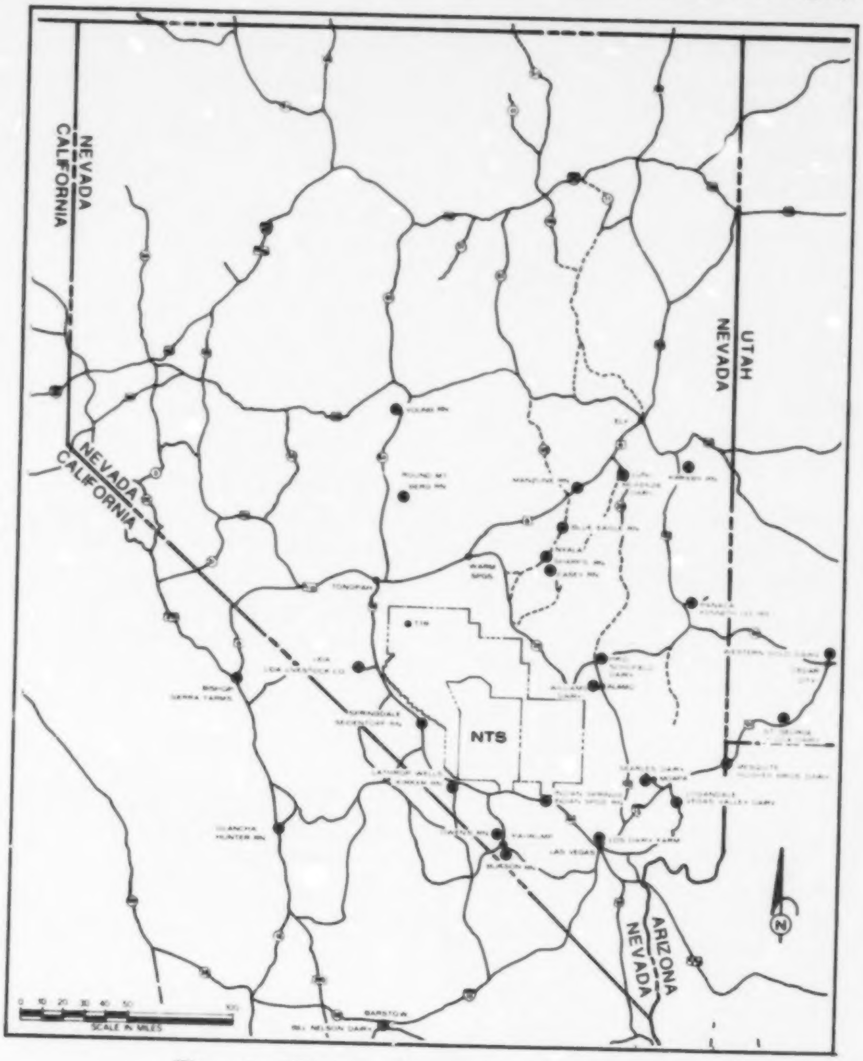
NEVADA
CALIFORNIA
NEVADA
CALIFORNIA
UTAH
NEVADA
ELY
TONOPAH
NTS
LAS VEGAS
BARSTOW
BISHOP
LIDA
ARIZONA
NEVADA
N
SCALE IN MILES
0
10
20
30
40
50
100

Figure 1. NERC-LV milk surveillance network

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area is conducted to determine radionuclide concentrations. Additional milk sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and analytical procedures was included with the milk results reported in the July 1973 issue of *Radiation Data and Reports.*

Results

The analytical results of all milk samples collected in August 1973 by NERC-LV surveillance programs are listed in table 1. Strontium-89 and -90 were not detected in any sample during this period. With the exception of cesium-137 at levels near the minimum detectable activity (MDA) of 10 pCi/liter, no gamma-emitting fission products were identified by gamma spectrometry in any of the samples collected in August. Levels of tritium near the MDA for this radionuclide (~200 pCi/liter) were also measured by liquid scintillation. The highest concentration of tritium during August 1973 was 800 ± 250 pCi/liter.

Table 1. Milk surveillance results, August 1973

Location	Date collected (August 1973)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)	
			Cesium-137	Tritium
California:				
Bishop:				
Sierra Farms	9	11	<10	NA
Hinkley:				
Bill Nelson Dairy	7	12	<10	NA
Olancha:				
Hunter Ranch	NS	13		
Nevada:				
Alamo:				
Williams Dairy	7	12	<10	NA
Austin:				
Young's Ranch	6	13	<10	560 ± 250
Currant:				
Blue Eagle Ranch	14	13	<10	NA
Manzonie Ranch	14	13	<10	NA
Hiko:				
Schofield Dairy	7	12	<10	400 ± 240
Indian Springs:				
Indian Springs Ranch	NS			
Las Vegas:				
LDS Dairy Farms	17	12	<10	360 ± 250
Lathrop Wells:				
Kirker Ranch	9	13	<10	NA
Lida:				
Lida Livestock Company	5	13	<10	NA
Logandale:				
Vegas Valley Dairy	14	12	<10	NA
Lund:				
McKenzie Dairy	13	12	<10	340 ± 250
Mesquite:				
Hughes Bros. Dairy	14	12	<10	350 ± 250
[illegible]:				
[illegible] Dairy	13	12	<10	NA
[illegible]:				
[illegible] Ranch	7	13	[c] <100	800 ± 250
[illegible]:				
[illegible] Ranch	8	13	<10	NA
[illegible]:				
[illegible] Ranch	8	13	<10	NA
[illegible]:				
[illegible] Ranch	6	13	<10	NA
[illegible]:				
[illegible] Ranch	NS			
[illegible]:				
[illegible] Ranch	7	13	<10	NA
Utah:				
Cedar City:				
Western Gold Dairy	15	12	<10	NA
St. George:				
R. Cox Dairy	14	12	<10	NA

[a] 11—pasteurized milk.
12—raw milk from Grade A producer(s).
13—raw milk from family cow(s).
[b] Two-sigma counting error provided when available.
[c] Small sample size increased minimum detectable activity.
NA, no analysis.
NS, no sample.

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	January–June 1971	December 1972
Carbon-14 in total Diet and Milk	1972–1973	November 1973
Institutional Diet	January–March 1973	November 1973

Radiostrontium in Milk, January–December 1972[1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

In 1954, the Health and Safety Laboratory began monitoring for strontium-90 in liquid whole milk to estimate the dietary contribution from the ingestion of the radionuclide from this source.

The New York City sample is a monthly composite of pasteurized milk purchased daily at retail stores. Five main dairies are represented in the sample. The powdered milk sampling at Perry, N.Y. was terminated at the end of 1969.

The strontium-90 to calcium ratios for New York for January–December 1972 are presented in table 1.

Previous coverage ***in Radiation Data and Reports:***

Period	Issue
January–December 1971	November 1972

Table 1. Strontium-90 to calcium ratios in milk, January-December 1972

Sampling location	Strontium-90 to calcium ratio (pCi/g)											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
New York, N.Y. (liquid whole milk)	5.9	5.5	5.6	6.1	7.7	7.3	7.7	6.0	5.0	6.2	6.4	5.4

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[1] Data summarized from "Fallout Program Quarterly Summary Report, October 1, 1973." HASL–276. Available from National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22151.

Strontium-90 in Tri-City Diets, January–December 1972

Health and Safety Laboratory
U.S. Atomic Energy Commission

Estimates of the average intake of strontium-90 by New York City, Chicago, and San Francisco residents have been made by the Health and Safety Laboratory (*HASL*). These estimates were made by using measurements of the strontium-90 content of a large variety of foods purchased at the cities every 3 months and statistics on the average consumption of each food compiled by the U.S. Department of Agriculture in their 1955 Household Diet Survey (*1*). A detailed description of the aims and methods of the *HASL* diet sampling program along with a summary of the results obtained during the first 3 years of operation (1960–1963) was published earlier (*2*).

In 1968, two changes were made in the program. The first change was the suspension of the collection and analysis of foods purchased in Chicago. Previous experience had shown the levels of strontium-90 in the Chicago diet to be consistently between those of New York City and San Francisco. Thus, reasonable estimates of the dietary intake of strontium-90 in Chicago at any time can be made from the analyses of foods purchased in New York City and San Francisco.

The second change, revision of the estimates of the annual consumption of different diet components, was made because new information became available. This new information on the composition of the diet appeared in a preliminary report of the U.S. Department of Agriculture in their 1965 Household Diet Survey (*3*). The changes in the composition of the diet from 1955 to 1965 are not very great, and the estimates of strontium-90 intake using statistics from either diet survey are not

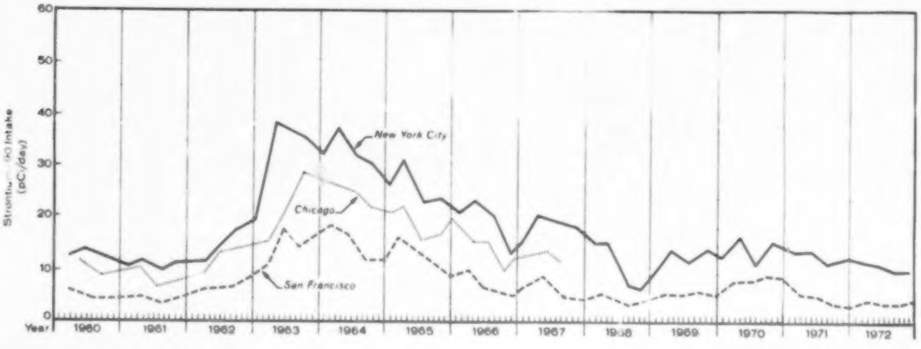

Figure 1. Daily intake of strontium-90 in tri-city diets, 1960–December 1972

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[1] Data from Fallout Program Quarterly Summary Report, HASL 257, 259 and 273. Available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va. 22151.

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Table 1. Average dietary consumption and strontium-90 intake in Tri-City diet, January-March 1972

Food category	Diet (kg/a)	Calcium (g/a)	Strontium-90			
			New York City February 1972		San Francisco March 1972	
			(pCi/kg)	(pCi/a)	(pCi/kg)	(pCi/a)
Dairy products	200	216.0	6.8	1,351	1.7	344
Fresh fruit	59	9.4	15.8	930	3.9	228
Fresh vegetables	48	18.7	12.2	585	5.4	258
Root vegetables	10	3.8	11.4	114	6.7	67
Potatoes	38	3.8	8.6	328	2.0	78
Macaroni	3	.6	4.2	13	3.5	11
Rice	3	1.1	1.8	5	1.5	4
Fruit juices	28	2.5	3.4	96	3.5	97
Canned vegetables	22	4.4	7.9	174	3.6	79
Canned fruit	11	.6	1.3	14	.9	10
Dried beans	3	2.1	19.5	58	10.2	31
Flour	34	6.5	6.1	206	3.3	111
Bakery products	44	53.7	6.4	283	3.3	147
Whole grain products	11	10.7	12.0	132	6.6	72
Fresh fish	8	7.6	.5	4	ND	
Shellfish	1	1.6	1.2	1	.8	1
Poultry	20	6.0	.5	10	.3	7
Meat	79	12.6	.7	54	.4	29
Eggs	15	8.7	1.6	24	1.4	21
Annual intake (pCi/a)		370		4,382		1,595
Daily intake (pCi/g Ca)				11.8		4.3

ND, nondetectable.

too different. Estimates of the intakes of other nuclides, however, may be affected to a greater degree. The new estimates of the consumption have therefore been used to calculate the intakes of calcium and strontium-90 for 1971 in New York City and San Francisco.

Results for January–December 1972 are presented in tables 1 through 4. The variation with time of the daily intake of strontium-90 in the three cities is plotted in figure 1.

Table 2. Average dietary consumption and strontium-90 intake in Tri-City diet, April-June 1972

Food category	Diet (kg/a)	Calcium (g/a)	Strontium-90			
			New York City May 1972		San Francisco June 1972	
			(pCi/kg)	(pCi/a)	(pCi/kg)	(pCi/a)
Dairy products	200	216.0	8.2	1,635	1.5	290
Fresh fruit	59	9.4	9.5	559	2.6	151
Fresh vegetables	48	18.7	16.6	798	2.7	131
Root vegetables	10	3.8	5.0	50	2.7	27
Potatoes	38	3.8	6.4	242	1.5	57
Macaroni	3	.6	4.2	13	3.7	11
Rice	3	1.1	1.2	4	1.5	5
Fruit juices	28	2.5	2.6	73	1.6	44
Canned vegetables	22	4.4	7.7	170	4.3	94
Canned fruit	11	.6	1.0	11	1.3	14
Dried beans	3	2.1	5.0	15	12.4	37
Flour	34	6.5	4.7	159	4.4	149
Bakery products	44	53.7	5.6	246	3.0	134
Whole grain products	11	10.3	10.3	114	6.1	67
Fresh fish	8	7.6	.5	4	ND	
Shellfish	1	1.6	1.3	1	ND	
Poultry	20	6.0	.4	9	.5	10
Meat	79	12.6	.4	35	.4	35
Eggs	15	8.7	1.7	25	1.2	17
Annual intake (pCi/a)		370		4,163		1,273
Daily intake (pCi/g Ca)				11.3		3.4

ND, nondetectable.

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Table 3. Average dietary consumption and strontium-90 intake in Tri-City diet, July-September 1972

Food category	Diet (kg/a)	Calcium (g/a)	Strontium-90			
			New York City August 1972		San Francisco September 1972	
			(pCi/kg)	(pCi/a)	(pCi/kg)	(pCi/a)
Dairy products	200	216.0	5.9	1,173	1.2	240
Fresh fruit	59	9.4	7.0	413	2.1	121
Fresh vegetables	48	18.7	13.0	623	1.1	53
Root vegetables	10	3.8	6.0	60	3.8	38
Potatoes	38	3.8	7.4	281	1.3	48
Macaroni	3	.6	4.7	14	4.1	12
Rice	3	1.1	1.7	5	1.8	6
Fruit juices	28	2.5	3.5	98	2.1	59
Canned vegetables	22	4.4	5.6	122	2.2	49
Canned fruit	11	.6	1.5	16	.8	9
Dried beans	3	2.1	14.5	44	4.4	13
Flour	34	6.5	6.8	232	3.4	115
Bakery products	44	53.7	6.6	292	2.5	111
Whole grain products	11	10.3	11.6	128	4.3	48
Fresh fish	8	7.6	.4	3	ND	----
Shell fish	1	1.6	.2	----	ND	----
Poultry	20	6.0	.5	10	.4	8
Meat	79	12.6	.5	40	.5	36
Eggs	15	8.7	2.8	41	1.4	22
Annual intake (pCi/a)		370		3,595		988
Daily intake (pCi/g Ca)				9.7		2.7

ND, nondetectable.

Table 4. Average dietary consumption and strontium-90 intake in Tri-City diet
October-December 1972

Food category	Diet (kg/a)	Calcium (g/a)	Strontium-90			
			New York City November 1972		San Francisco December 1972	
			(pCi/kg)	(pCi/a)	(pCi/kg)	(pCi/a)
Dairy products	200	216.0	6.7	1,331	1.5	290
Fresh fruit	59	9.4	8.0	475	2.3	137
Fresh vegetables	48	18.7	14.1	678	2.4	113
Root vegetables	10	3.8	6.3	63	5.7	57
Potatoes	38	3.8	4.1	155	3.8	143
Macaroni	3	.6	4.2	13	4.4	13
Rice	3	1.1	1.3	4	1.3	4
Fruit juices	28	2.5	2.8	80	2.1	60
Canned vegetables	22	4.4	7.6	166	3.1	69
Canned fruit	11	.6	1.2	13	1.2	13
Dried beans	3	2.1	10.4	31	29.9	90
Flour	34	6.5	6.4	216	[a] 3.5	118
Bakery products	44	53.7	3.4	150	3.2	141
Whole grain products	11	10.3	9.8	108	5.0	55
Fresh fish	8	7.6	ND	----	ND	----
Shell fish	1	1.6	1.0	1	ND	----
Poultry	20	6.0	.6	11	.8	16
Meat	79	12.6	ND	----	.5	40
Eggs	15	8.7	.3	4	1.1	16
Annual intake (pCi/a)		370		3,499		1,375
Daily intake (pCi/g Ca)				9.5		3.7

[a] Estimated.
ND, nondetectable.

REFERENCES

(1) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, household food consumption survey, Report No. 1 (1955). Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (December 1956).

(2) RIVERA, J. and J. H. HARLEY. HASL contributions to the study of fallout in food chains, HASL-137. Office of Technical Services, U.S. Atomic Energy Commission, New York, N.Y. (July 1, 1964).

(3) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, spring 1965, A Preliminary Report. USDA, ARS 62-16 (August 1967).

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SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter of gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

Water sampling program	Period reported	Issue
California	January–December 1971 and 1972	November 1973
Colorado River Basin	1968	March 1972
Community Water Supply Study	1968	September 1972
Florida	1969	January 1972
Interstate Carrier Drinking Water	1971	May 1972
Kansas	January–December 1971	February 1973
Michigan	January–June 1970	November 1971
Minnesota	July 1970–June 1971	November 1972
New York	July–December 1971	August 1973
North Carolina	1968–1970	September 1972
Tritium Surveillance System	April–June 1973	October 1973
Washington	July 1970–June 1971	August 1973
Water Surveillance Programs, *NERC-LV*	June–July 1973	November 1973

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies, Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

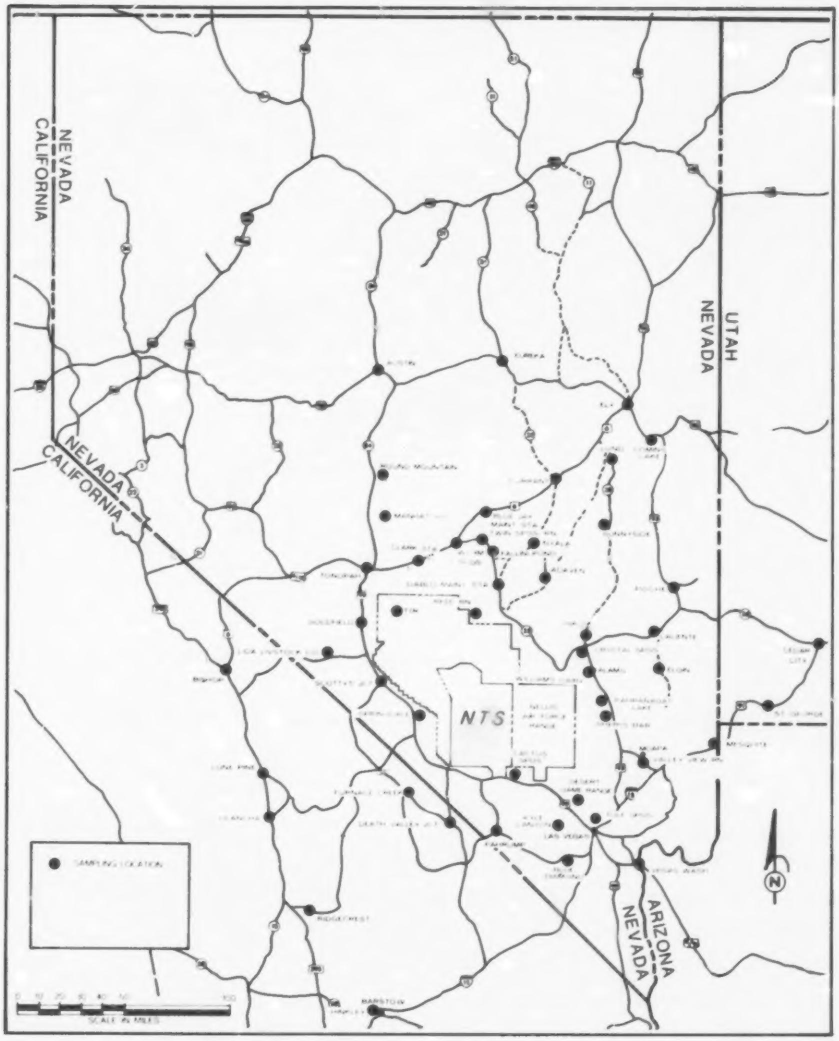
(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Water Surveillance Programs, August 1973

National Environmental Research Center-Las Vegas, Environmental Protection Agency

The Water Surveillance Network, operated by the National Environmental Research Center-Las Vegas (NERC-LV), consists of 59 sampling locations (figures 1 and 2) in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing programs sponsored by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site.[1]

In the event of a release of radioactivity from the NTS, special sampling within the affected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BISHOP
SCOTTY'S JCT
LONE PINE
FURNACE CREEK
DEATH VALLEY JCT
RIDGECREST
BARSTOW
NTS
NELLIS AIR FORCE RANGE
CACTUS SPGS
SUNNYSIDE
PIOCHE
CALIENTE
CRYSTAL SPGS
ALAMO
PAHRANAGAT LAKE
CEDAR CITY
ST GEORGE
MESQUITE
MOAPA
DESERT GAME RANGE
LAS VEGAS
PAHRUMP
SAMPLING LOCATION
SCALE IN MILES
N

Figure 1. NERC-LV water surveillance network

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[1] This network is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. AEC, Las Vegas, Nev.

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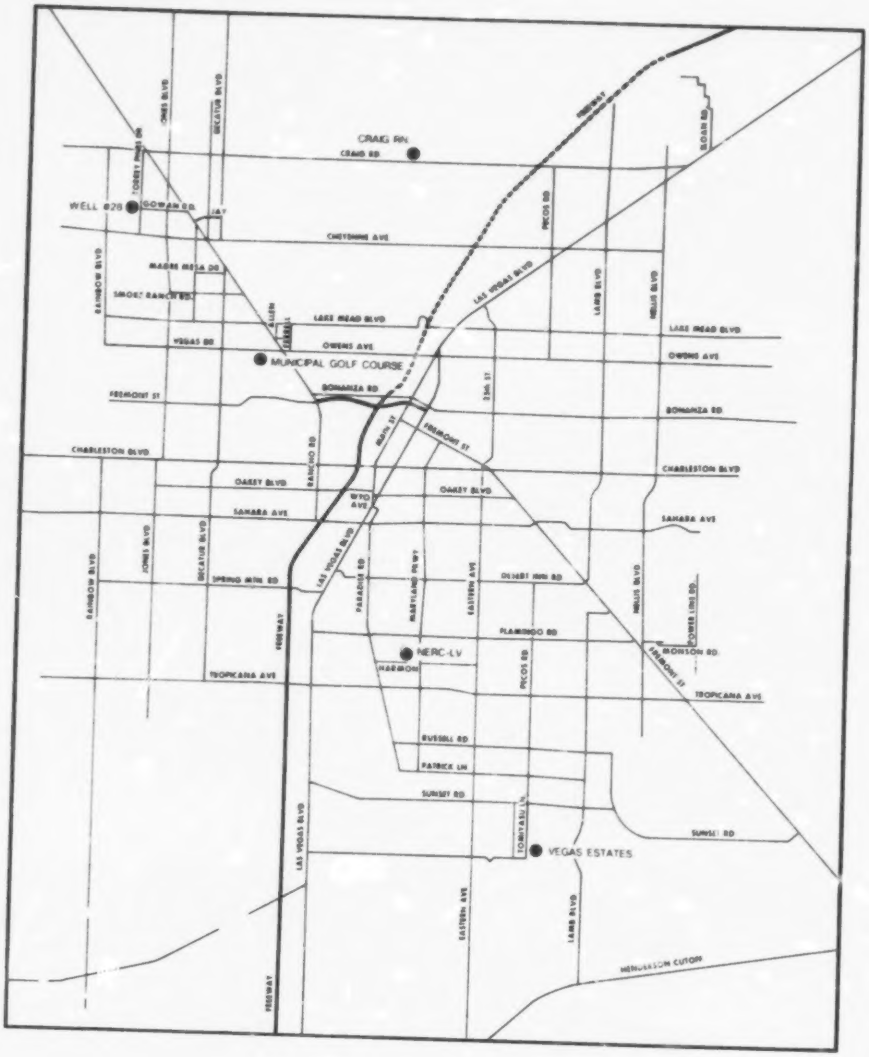
CRAIG RN
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SMOKE RANCH RD
LAKE MEAD BLVD
VEGAS DR
OWENS AVE
MUNICIPAL GOLF COURSE
BONANZA RD
FREMONT ST
CHARLESTON BLVD
OAKEY BLVD
SAHARA AVE
SPRING MTN RD
DESERT INN RD
FLAMINGO RD
NERC-LV
HARMON
TROPICANA AVE
RUSSELL RD
PATRICK LN
SUNSET RD
VEGAS ESTATES
HENDERSON CUTOFF
RAINBOW BLVD
JONES BLVD
DECATUR BLVD
RANCHO RD
FREEWAY
LAS VEGAS BLVD
PARADISE RD
MARYLAND PKWY
EASTERN AVE
PECOS RD
LAMB BLVD
NELLIS BLVD
SLOAN RD
BORAN ST
TORREY PINES DR
ALLEN
JAY
WYO AVE
MAIN ST
25TH ST
TOPAZ LN
BOULDER HWY
LAS VEGAS BLVD
MONSON RD

Figure 2. NERC-LV water surveillance network, Las Vegas valley

areas is conducted to determine radionuclide concentrations. Additional water sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and routine analytical procedures was included with the water results reported in the July 1973 issue of *Radiation Data and Reports.*

Results

The routine analytical results of all water samples collected in August 1973 by the NERC-LV water surveillance network are listed in table 1. No gamma-emitting fission products were identified by gamma spectrometry in any of the August samples. The analytical results for calendar year 1973 samples selected for special analyses will be reported at a later date.

Table 1. Water surveillance results, August 1973

Location	Date collected (August 1973)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
California:					
Bishop:					
Fish and Game Office	9	23	<1.6	<3.5	NA
Death Valley Junction:					
Lila's Cafe	NS	23			
Furnace Creek:					
Pond	10	21	<3.0	<3.6	NA
Visitor's Center	10	27	<2.4	7.8 ± 3.8	NA
Hinkley:					
Bill Nelson Dairy	7	23	5.7 ± 4.6	4.2 ± 3.6	NA
Lone Pine:					
Forest Service Ranger Station	8	24	<1.3	<3.5	NA
Olancha:					
Haiwee Reservoir	7	21	<1.3	<3.5	NA
Ridgecrest:					
City Hall	7	23	<3.4	<3.5	NA
Nevada:					
Adaven:					
Canfield Ranch	7	22	<2.3	<3.4	NA
Alamo:					
Pahranagat Lake	7	21	14 ± 6.8	22 ± 4.6	NA
Sheri's Bar	7	23	<2.7	<3.5	NA
Williams Dairy	7	23	5.0 ± 4.3	10 ± 4.0	NA
Austin:					
Nevada National Bank	5	27	20 ± 5.8	6.0 ± 3.5	NA
Blue Diamond:					
Post Office	1	23	3.9 ± 3.7	<3.5	<240
Blue Jay Highway:					
Maintenance Station	9	23	3.3 ± 3.2	<3.4	NA
Cactus Springs:					
Mobil Service Station	6	27	<2.0	<3.3	290 ± 240
Caliente:					
Agricultural Extension Station	9	23	4.3 ± 3.2	<3.3	NA
Clark Station:					
Five Mile Ranch	9	27	<1.6	5.7 ± 3.5	NA
Currant:					
Currant Ranch Cafe	14	27	<3.0	4.9 ± 3.5	NA
Diablo:					
Highway Maintenance Station	7	23	3.2 ± 3.0	8.0 ± 3.6	NA
Reed Ranch	6	21	19 ± 6.7	8.1 ± 3.7	NA
Elgin:					
Water tower	9	23	4.8 ± 4.2	5.9 ± 3.7	NA
Ely:					
Chevron Service Station	13	24	3.7 ± 2.6	<3.3	NA
Comins Lake	13	21	7.7 ± 4.9	26 ± 4.6	NA
Eureka:					
Highway Maintenance Station	1	24	9.4 ± 4.5	<3.5	NA
Goldfield:					
Chevron Service Station	6	23	<2.6	<3.5	NA
Hiko:					
Crystal Springs	7	27	5.7 ± 3.6	<3.5	NA
Schofield Dairy	7	23	33 ± 9.3	25 ± 4.7	NA
Las Vegas:					
Craig Ranch Golf Course	13	23	3.4 ± 3.0	<3.5	<240
Desert Game Range	13	24	<2.4	<3.3	<240
Lab II NERC	13	24	<3.7	4.6 ± 3.7	830 ± 250
Lake Mead Vegas wash	13	21	<4.2	6.8 ± 3.7	870 ± 250
Las Vegas Water District well 28	13	23	3.9 ± 2.9	<3.3	<240
Municipal Golf Course	13	23	<1.9	<3.3	<240
Tule Springs	13	23	3.4 ± 2.7	<3.3	<240
Tule Springs Pond	13	21	<1.8	<3.3	NA
Vegas Estates	13	23	5.2 ± 4.9	9.5 ± 4.0	260 ± 240
Lida:					
Lida Livestock Company	6	27	<2.4	<3.5	NA
Pond at storage tank	6	21	4.5 ± 3.4	8.0 ± 3.6	NA
Lund:					
Gardner Grocery	13	23	2.8 ± 2.7	<3.3	NA
Manhattan:					
Country store	7	23	14 ± 6.4	3.9 ± 3.5	NA
Mesquite:					
Hughes Bros. Dairy	14	23	<3.4	4.9 ± 3.6	NA
Moapa:					
Pedersen Valley View Ranch	14	27	5.3 ± 4.6	11 ± 3.9	NA
Mt. Charleston:					
Kyle Canyon Fire Station	13	27	<1.9	<3.3	<240
Nyala:					
Sharp's Ranch	7	23	3.4 ± 2.7	<3.3	NA
Pahrump:					
Texaco Service Station	8	23	4.3 ± 3.0	<3.3	NA
Pioche:					
County courthouse	8	24	2.8 ± 2.6	<3.5	NA

See footnotes at end of table.

Table 1. Water surveillance results, August 1973—continued

Location	Date collected (August 1973)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
Round Mountain:					
Mobil Service Station	7	27	4.0 ± 3.0	<3.3	NA
Scotty's Junction:					
Chevron Service Station	6	23	6.9 ± 5.1	7.7 ± 3.8	360 ± 230
Springdale:					
Pond	7	21	<4.1	7.5 ± 3.7	NA
Sunnyside:					
Adam McGill Reservoir	13	21	<2.7	3.5 ± 3.4	NA
Wildlife Management Headquarters	13	27	<2.1	<3.3	NA
Tonopah:					
Jerry's Chevron Station	8	23	4.3 ± 3.2	4.8 ± 3.6	NA
Tonopah Test R. [illegible] CP-1	8	23	4.6 ± 3.6	4.5 ± 3.5	NA
Warm Springs:					
Fallini's Pond	NS	21			
Service Station and Cafe	9	27	20 ± 8.5	25 ± 4.7	NA
Twin Springs Ranch	9	23	5.1 ± 3.8	5.6 ± 3.5	NA
Utah:					
Cedar City:					
M. D. Baldwin Residence	15	24	<1.3	<3.3	NA
St. George:					
R. Cox Dairy	14	24	2.4 ± 1.8	<3.3	NA

[a] 21—Pond, lake, reservoir, stock tank, stock pond.
22—Stream, river, creek.
23—Well.
24—Multiple supply mixed (a water sample consisting of mixed or multiple sources of water such as well and spring).
27—Spring.

[b] Two-sigma counting error provided when available.
NA, not analyzed.
NS, no sample.

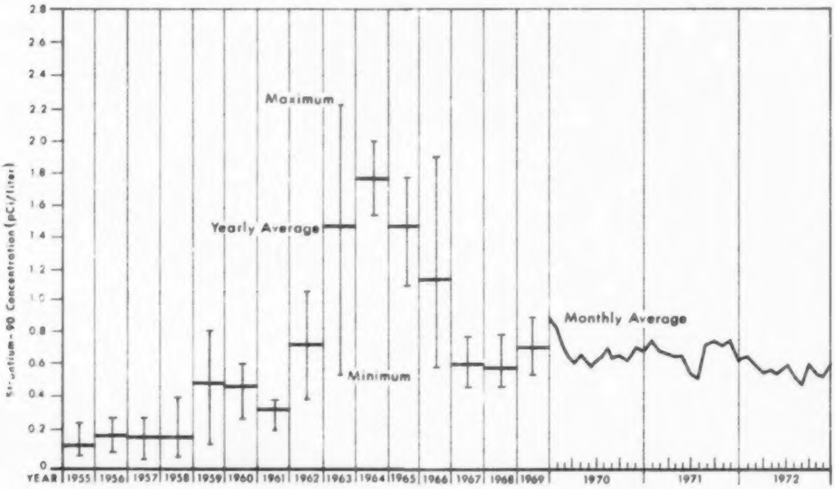

Figure 1. Strontium-90 concentration in New York City tap water 1955–December 1972

Radiostrontium in Tap Water, January–December 1972[1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

The Health and Safety Laboratory has performed analyses for strontium-90 in tap water of New York City since August 1954. Samples of tap water are collected daily so that by the end of the month a composite of at least 100 liters is available for analysis. Cesium-137 determinations were begun in January 1964. The analytical methods used at the laboratory are given in the Health and Safety Laboratory Manual of Standard Procedures (*1*).

Strontium-90 concentrations and cesium-137 to strontium-90 ratios in New York City tap water for January through December 1972 are presented in table 1. These results appear graphically in figure 1.

A decreasing trend has been observed in the strontium-90 concentrations since the July 1963 peak. The maximum strontium-90 concentrations observed are below the acceptable limit as set forth in the interstate carrier drinking water standards (*2*).

Table 1. Radiostrontium in New York City tap water January-December 1972

Month (1972)	Strontium-90[a] (pCi/liter)	Cesium-137/ strontium-90
January	0.65	0.12
February	.59	.11
March	.54	.10
April	.56	.08
May	.54	.10
June	.59	.10
July	.51	.10
August	.46	(b)
September	.60	(b)
October	.54	(b)
November	.53	.09
December	.60	.07

[a] Approximately 100 liters per sample.
[b] No cesium-137 analysis.

REFERENCES

(*1*) U.S. ATOMIC ENERGY COMMISSION. Manual of standard procedures 40:E-38-01-16. Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York, N.Y. 10014.

(*2*) FEDERAL REGISTER RULES AND REGULATIONS. Title 42–Public Health, Chapter 1, Public Health Service, Department of Health, Education, and Welfare; Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards 27:2154–2155. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 6, 1962).

Previous coverage in *Radiation Data and Reports:*

Period	Issue
July–December 1971	November 1972

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[1] Prepared from information appearing in Fallout Program Quarterly Summary Report, HASL–276 (October 1, 1973). This report is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22151.

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SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Pan American Health Organization, and the California Air Sampling Program.

In addition to those programs presented in this issue, the following programs were covered previously in *Radiation Data and Reports.*

Network	Period	Issue
Fallout in the United States and other areas	1971	August 1973
Plutonium in airborne particulates	October–December 1972	June 1973
Surface air sampling program, 80th Meridian Network, *HASL*	January–December 1971	September 1973

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1. Radiation Alert Network
August 1973

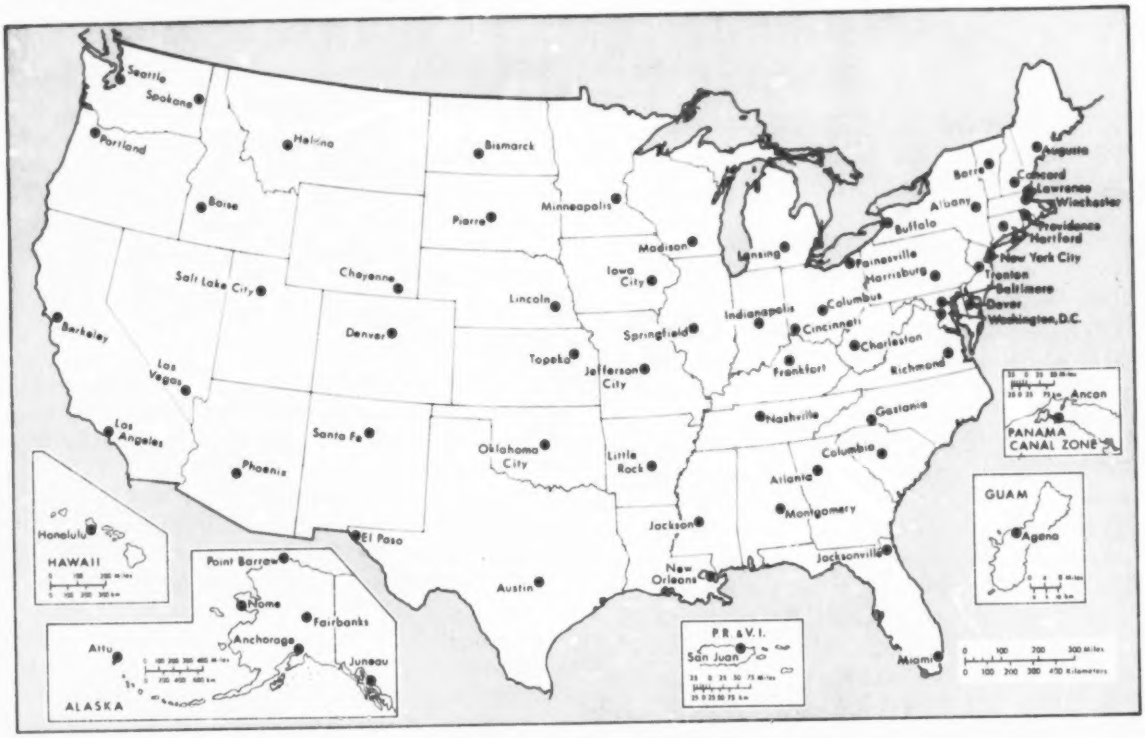
Eastern Environmental Radiation Facility
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which gathers samples at 68 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. The airborne particulate samples and precipitation samples are sent to the Eastern Environmental Radiation Facility for further analysis. All field estimate results are reported to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily measurements is available upon request from the Eastern Environmental Radiation Facility, Montgomery, Ala. 36109. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate and laboratory techniques during August 1973.

The Office of Radiation Programs is in the process of modifying the air program to make it more responsive to potential sources of environmental radioactivity. These changes will be reflected in future articles.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Albany
Barre
Augusta
Concord
Lawrence
Winchester
Providence
Hartford
New York City
Trenton
Baltimore
Dover
Washington, D.C.
Painesville
Harrisburg
Columbus
Indianapolis
Cincinnati
Charleston
Frankfort
Richmond
Springfield
Denver
Berkeley
Las Vegas
Topeka
Jefferson City
Los Angeles
Santa Fe
Oklahoma City
Little Rock
Nashville
Gastonia
Columbia
Atlanta
Montgomery
Phoenix
Jackson
El Paso
Austin
New Orleans
Jacksonville
Miami
Ancon
PANAMA CANAL ZONE
GUAM
Agana
Honolulu
HAWAII
Point Barrow
Nome
Fairbanks
Anchorage
Attu
Juneau
ALASKA
P.R. & V.I.
San Juan
0 100 200 300 Miles
0 100 200 300 400 Kilometers

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, August 1973

Station location		Number of samples	Gross beta radioactivity (pCi/m³)						Precipitation	
			5-hour field estimate			Laboratory measurement			Laboratory estimate of deposition	
			Maximum	Minimum	Average[a]	Maximum	Minimum	Average[a]	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	23	3	0	1	0.03	0.01	0.02	90	0.26
Alaska:	Anchorage	2	0	0	0	.02	<.01	.01		
Calif:	Berkeley	9	0	0	0	.01	<.01	<.01		
	Los Angeles	9	1	0	0	.05	.02	.03		
Colo:	Denver	9	2	1	2	.06	.03	.04	12	.14
Del:	Dover	17	1	0	0	.07	.01	.03		
Ind:	Indianapolis	22	2	0	1	.04	.02	.03		
Nev:	Las Vegas	22	3	1	2	.08	<.01	.04		
N. Mex:	Santa Fe	4	1	1	1	.03	.01	.02	50	.20
N.Y:	Buffalo	9	1	0	1	.06	.02	.04		
N. Dak:	Bismarck	9	2	1	1	.05	.01	.03	5	.05
Ohio:	Columbus	8	3	0	1	.05	.03	.04		
Okla:	Oklahoma City	7	2	0	1	.04	.02	.03		
Oreg:	Portland	23	0	0	0	.02	<.01	.01		
Pa:	Harrisburg	22	3	0	1	.06	<.01	.03		
S.C:	Columbia	8	3	0	1	.05	.03	.04	165	.87
Utah:	Salt Lake City	13	3	0	2	.05	.02	.04		
Network summary		216	3	0	1	0.08	<0.01	0.03	64	0.30

[a] The monthly average is calculated by weighting the measurements of individual air samples with length of sampling period.

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2. Air Surveillance Network, August 1973

National Environmental Research Center-Las Vegas[1]
Environmental Protection Agency

The Air Surveillance Network [2] (ASN), operated by the National Environmental Research Center-Las Vegas (NERC-LV), consists of 49 active and 72 standby sampling stations located in 21 Western States (figures 2 and 3). The network is operated in support of nuclear testing sponsored by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), and at any other designated testing sites.

The stations are operated by State Health department personnel and by private individuals on a contract basis. All active stations are operated continuously with filters being changed over periods generally ranging from 24 to 72 hours. All samples are mailed to the NERC-LV unless special retrieval is arranged at selected locations in response to known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports*.

Results

Table 2 presents the average gross beta concentrations in air for each of the network stations. The minimum reporting concentration for gross beta activity is 0.1 pCi/m³. For reporting purposes, concentrations less than 1.0 pCi/m³ are reported to 1 significant figure, and those equal to or greater than 1.0 pCi/m³ are reported to 2 significant figures. For averaging purposes individual concentration values less than the minimum detectable concentration (~0.06 pCi/m³ for a 350 m³ sample) are set equal to the minimum detectable concentration (MDC). Reporting and rounding-off conventions are indicated as follows:

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[1] Formerly the Western Environmental Research Laboratory.

[2] The ASN is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

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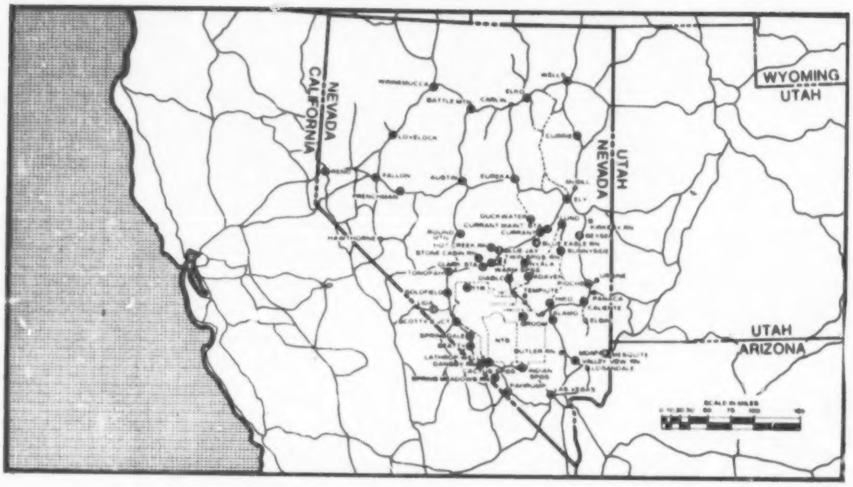
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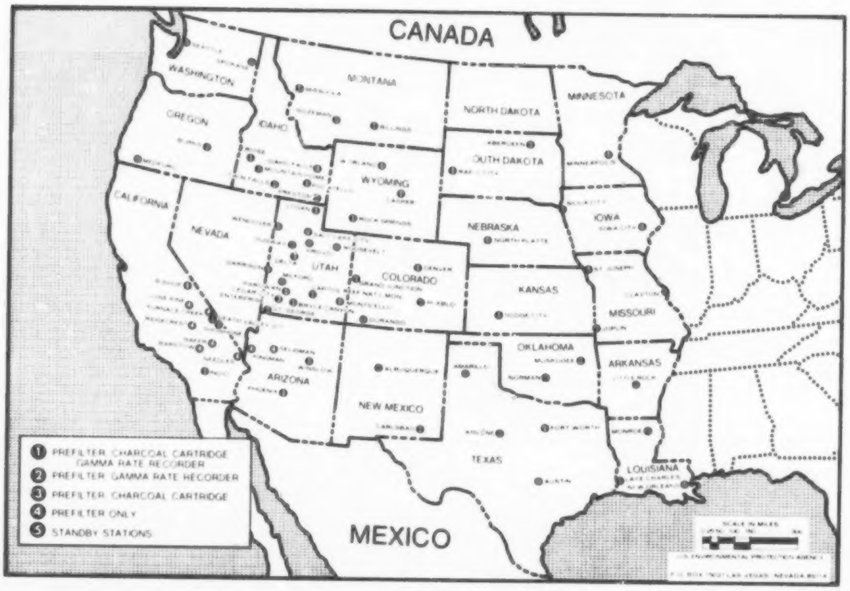
UTAH
NEVADA
WYOMING
UTAH
UTAH
ARIZONA
WINNEMUCCA
BATTLE MTN
CARLIN
ELKO
WELLS
LOVELOCK
FALLON
AUSTIN
EUREKA
ELY
HAWTHORNE
TONOPAH
GOLDFIELD
BEATTY
NTS
LAS VEGAS
PAHRUMP
CALIENTE
ALAMO
PIOCHE
MESQUITE
OVERTON
SCALE IN MILES

Figure 2. NERC-LV air surveillance network stations in Nevada


CANADA
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WASHINGTON
OREGON
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IDAHO
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MONTANA
WYOMING
UTAH
COLORADO
ARIZONA
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
① PREFILTER, CHARCOAL CARTRIDGE GAMMA RATE RECORDER
② PREFILTER, GAMMA RATE RECORDER
③ PREFILTER, CHARCOAL CARTRIDGE
④ PREFILTER ONLY
⑤ STANDBY STATIONS
SCALE IN MILES
U.S. ENVIRONMENTAL PROTECTION AGENCY
P.O. BOX 15027 LAS VEGAS, NEVADA 89114

Figure 3. NERC-LV air surveillance network stations outside Nevada

Concentration (pCi/m³)	Reported value of concentration above MDC (pCi/m³)	Reported value of concentration below MDC (pCi/m³)
<0.05	< 0.1	<0.1
≥ .05 <0.15	.1	< .1
≥ .15	As calculated and rounded	calculated MDC

As shown by table 2, the highest gross beta concentration within the network was 0.3 pCi/m³ at Fallini's Twin Springs Ranch, Hiko and Scotty's Junction, Nev. No radionuclides were identified by gamma spectrometry on any filters or charcoal cartridges during August.

Complete copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA Regional Offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC-LV upon written request.

Table 2. Summary of gross beta radioactivity concentration in air August 1973

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average
Ariz:	Kingman	31	0.2	<0.1	0.1
	Seligman	31	.2	<.1	.1
Calif:	Baker	27	.1	<.1	.1
	Barstow	31	.1	<.1	.1
	Bishop	31	.2	<.1	.1
	Death Valley Junction	31	.1	<.1	.1
	Furnace Creek	31	.2	<.1	.1
	Lone Pine	27	.1	<.1	.1
	Needles	28	.1	<.1	.1
	Ridgecrest	31	.1	<.1	.1
	Shoshone	25	.1	<.1	.1
Nev:	Alamo	30	.2	<.1	.1
	Austin	24	.1	<.1	.1
	Beatty	30	.2	<.1	.1
	Blue Eagle Ranch (Currant)	27	.2	<.1	.1
	Blue Jay	31	.2	<.1	.1
	Caliente	31	.2	<.1	.1
	Currant Ranch	31	.2	<.1	.1
	Diablo	31	.1	<.1	.1
	Duckwater	28	.2	<.1	.1
	Ely	28	.1	<.1	.1
	Eureka	31	.1	<.1	.1
	Fallini's Twin Springs Ranch	31	.3	<.1	.1
	Geyser Ranch (Pioche)	27	.2	<.1	.1
	Goldfield	28	<.2	<.1	.1
	Groom Lake	21	.2	<.1	.1
	Hiko	31	.3	<.1	.1
	Indian Springs	31	.1	<.1	.1
	Las Vegas	22	.2	<.1	.1
	Lathrop Wells	31	.1	<.1	.1
	Lida	31	.1	<.1	.1
	Lund	31	.1	<.1	.1
	Mesquite	31	.2	<.1	.1
	Nyala	31	.1	<.1	.1
	Pahrump	31	.2	<.1	.1
	Pioche	31	.1	<.1	.1
	Round Mountain	31	.1	<.1	.1
	Scotty's Junction	28	.3	<.1	.1
	Stone Cabin Ranch	31	.1	<.1	.1
	Sunnyside	31	.2	<.1	.1
	Tonopah	31	.1	<.1	.1
	Tonopah Test Ranch	18	.2	<.1	.1
	Warm Springs	29	.2	<.1	.1
	Warm Springs Ranch	31	.1	<.1	.1
Utah:	Bryce Canyon	15	<.1	<.1	.1
	Cedar City	17	.1	<.1	.1
	Delta	28	<.2	<.1	.1
	Garrison	31	.2	<.1	.1
	Milford	30	.1	<.1	.1
	St. George	31	.1	<.1	.1

3. Canadian Air and Precipitation Monitoring Program,[3] August 1973

Radiation Protection Division
Department of National Health
and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 4), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for August 1973 are presented in table 3.

Table 3. Canadian gross beta radioactivity in surface air and precipitation, August 1973

Location	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	4	0.02	0.01	0.01	6.8	0.5
Coral Harbour	3	.06	.01	.02	6.0	.4
Edmonton	4	.02	.01	.01	4.1	4.8
Ft. Churchill	3	.01	<.01	.01	34.6	1.9
Fredericton	3	.01	.01	.01	5.5	1
Goose Bay	3	.01	.01	.01	3.1	.2
Halifax	4	.02	.01	.01	3.9	.4
Inuvik	4	.01	<.01	.01	8.9	.4
Montreal	4	.02	<.01	.01	11.8	1
Moosonee	4	.02	.01	.01	18	.7
Ottawa	3	.04	.01	.02	10.5	1.1
Quebec	4	.02	.01	.01	NS	NS
Regina	4	.03	.02	.01	27.6	.9
Resolute	3	.01	<.01	.01	16.6	.4
St. John's, Nfld	3	.01	.01	.01	NS	NS
Saskatoon	4	.02	.01	.01	NS	NS
Sault Ste. Marie	4	.03	.02	.01	9.4	1
Thunder Bay	4	.02	.01	.01	9	1.2
Toronto	3	.02	.01	.01	2.1	.1
Vancouver	4	.01	.01	.01	NS	NS
Whitehorse	4	.04	<.01	.01	NS	NS
Windsor	NS				36.2	1.7
Winnipeg	4	.02	.02	.01	10.5	.7
Yellowknife	4	.01	<.01	<.01	6	.8
Network summary	84	0.06	<0.01	0.01	12	1.6

NS, no sample.

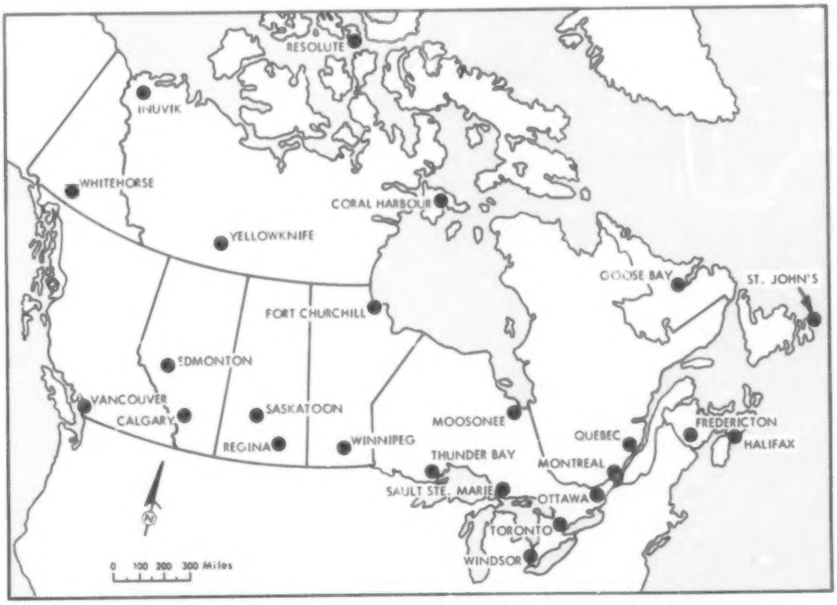
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
N
0 100 200 300 Miles

Figure 4. Canadian air and precipitation sampling stations

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[3] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

4. Pan American Air Sampling Program
August 1973

Pan American Health Organization and
U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The August 1973 air monitoring results from the participating countries are given in table 4.

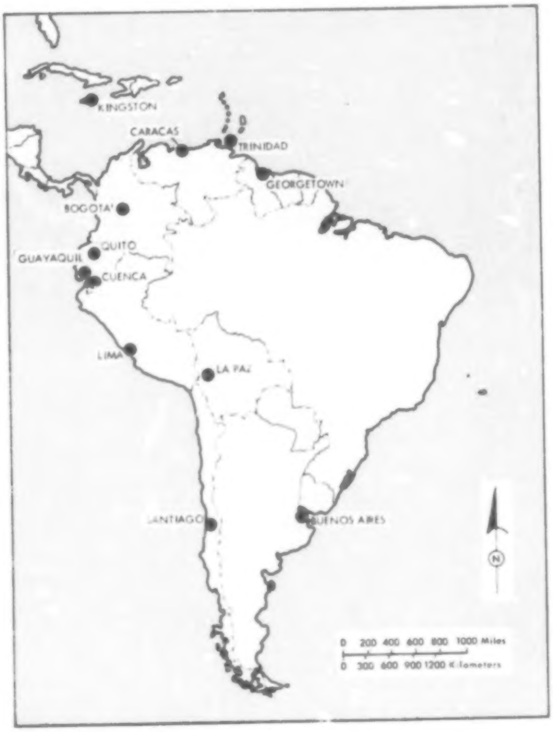

Figure 5. Pan American Air Sampling Program stations

Table 4. Summary of gross beta radioactivity in Pan American surface air, August 1973

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	16	1.4	0.01	0.07
Chile:	Santiago	30	9.2	.00	.86
Colombia:	Bogota	21	.04	.00	.01
Ecuador:	Cuenca	22	.83	.00	.07
	Guayaquil	21	6.1	.00	.97
	Quito	4	.01	.00	.00
Guyana:	Georgetown	0			
Jamaica:	Kingston	0			
Peru:	Lima	15	13.5	.04	2.22
Venezuela:	Caracas	16	.08	.00	.02
West Indies:	Trinidad	10	.16	.02	.07
Pan American summary		155	13.5	0.00	0.54

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

5. California Air Sampling Program
August 1973

Radiologic Health Section
California Department of Health

The Radiologic Health Section of the California Department of Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 6.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Health where they are analyzed for their radioactive content.

Airborne particules are collected by a con-

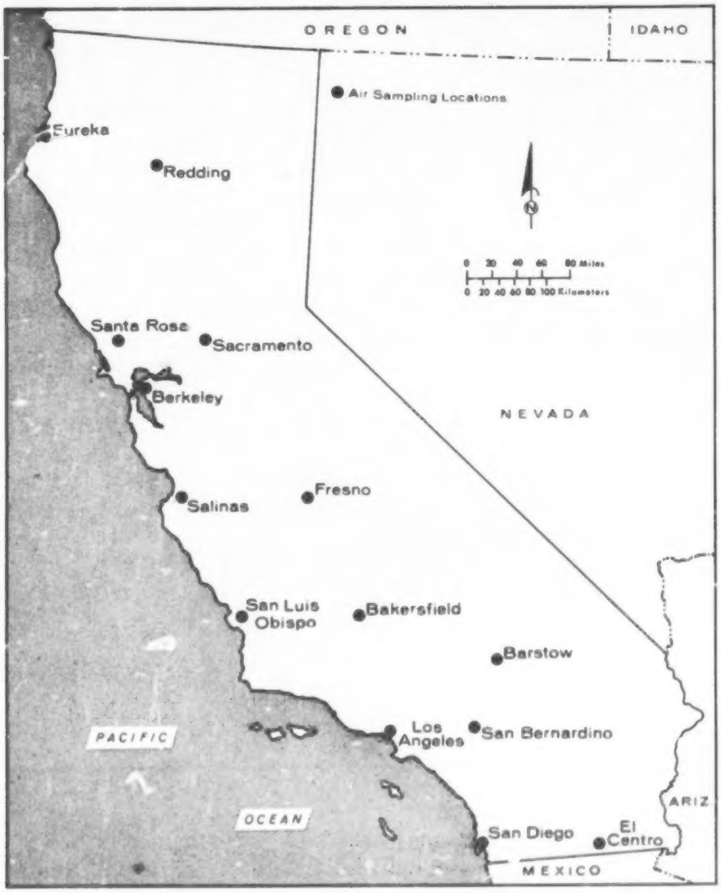
OREGON
IDAHO
Air Sampling Locations
Eureka
Redding
N
0 20 40 60 80 Miles
0 20 40 60 80 100 Kilometers
Santa Rosa
Sacramento
Berkeley
NEVADA
Salinas
Fresno
San Luis Obispo
Bakersfield
Barstow
PACIFIC
Los Angeles
San Bernardino
OCEAN
ARIZ
San Diego
El Centro
MEXICO

Figure 6. California air sampling program stations

tinuous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity, 72 hours after the end of the collection period. The daily samples then are composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. Table 5 presents the monthly gross beta radioactivity in air for August 1973. The monthly sample results are presented quarterly.

Table 5. Gross beta radioactivity in California air August 1973

Station location	Number of samples	Gross beta radioactivity (pCi/m^3)		
		Maximum	Minimum	Average
Bakersfield	31	1.12	0.08	0.29
Barstow	31	.75	.06	.20
Berkeley	31	.07	.00	[illegible]
El Centro	26	1.23	.01	.18
Eureka	29	.13	.00	[illegible]
Fresno	31	1.21	.04	.14
Los Angeles	30	.21	.05	.06
Redding	31	.46	.07	.16
Sacramento	31	.51	.02	.11
Salinas	31	3.23	.00	[illegible]
San Bernardino	31	.38	.00	.17
San Diego	30	.31	.02	.08
San Luis Obispo	31	.54	.03	.12
Santa Rosa	27	.20	.00	.06
Summary	421	3.23	0.00	[illegible]

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6. Mexican Air Monitoring Program January–June 1973

Instituto Nacional de Energía Nuclear
México, D.F.

The Radiation Surveillance Network of Mexico is operated by the Instituto Nacional de Energía Nuclear (INEN).

In the Instituto Nacional de Energía Nuclear, the Comité de Seguridad Radiológica (Radiological Security Committee) (CSR) is responsible for radiological protection. The Environmental Radioactivity Section (Sección de Radioactividad Ambiental) of the CSR is in charge of monitoring and measuring environmental radioactive contamination in general, including radiation in mines, uranium milling plant, and the Nuclear Center of Mexico.

Since radioactivity in air particulates have decreased to very low levels in the past few years, the objective of the air monitoring program has been changed from an alert type of network to emphasize dose assessment.

Measurements will continue in the following 6 areas: México City, D.F., Chihuahua, Ensenada, Torreón, Veracruz, and Mérida (figure 7). The sampling and analysis procedures were described previously (*6*).

The maximum, minimum, and average beta radioactivity in surface air from January through June 1973 are presented in table 6. Statistically, it has been found that a minimum of five samples per month was needed to get a reliable average radioactivity at each station (*7*).

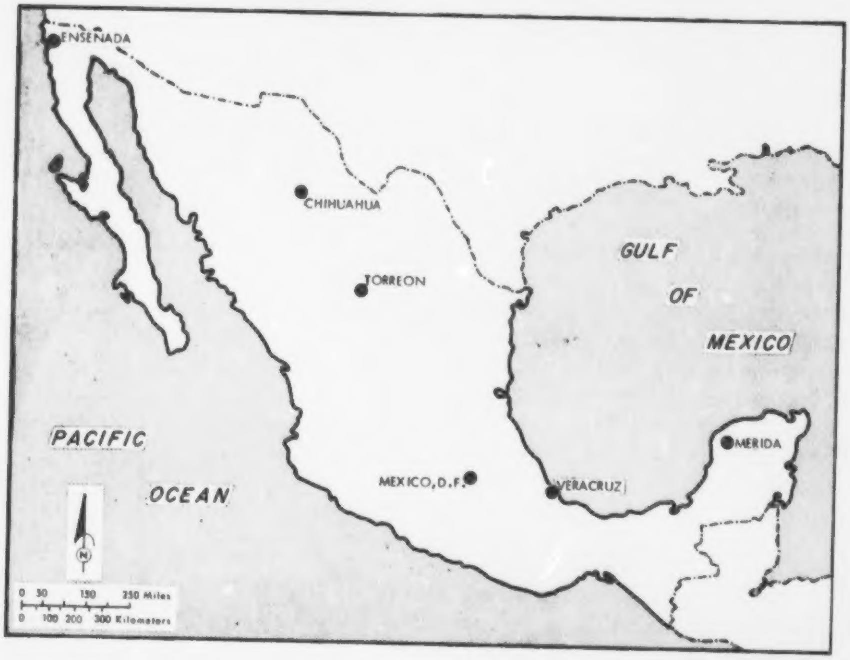

Figure 7. Mexican air sampling locations

Table 6. Mexican gross beta radioactivity of airborne particulates January-June 1973[a]

Station	Gross beta radioactivity (pCi/m³)					
	January	February	March	April	May	June
Chihuahua:						
Maximum	0.32	0.15	<0.2	<0.2	0.17	0.10
Minimum	.04	.04	<.2	<.2	.04	.04
Average	.11	.07	<.2	<.2	.08	.07
Ensenada:						
Maximum	NS	NS	<.2	<.2	NS	.13
Minimum	NS	NS	<.2	<.2	NS	<.03
Average	NS	NS	<.2	<.2	NS	.07
Mérida:						
Maximum	.1	.16	<.2	<.2	.11	.07
Minimum	.05	.08	<.2	<.2	.04	.04
Average	.07	.11	<.2	<.2	.07	.06
México, D.F:						
Maximum	.05	.08	<.6	<.2	.10	NS
Minimum	NS	.04	<.2	<.2	.04	NS
Average	(b)	.05	<.2	(b)	.07	(b)
Torreon:						
Maximum	.16	.12	<.2	<.2	.10	.09
Minimum	.11	.05	<.2	<.2	.05	.03
Average	.12	.08	<.2	<.2	.08	.06
Veracruz:						
Maximum	.09	.10	<.2	<.2	.11	.11
Minimum	<.03	.06	<.2	<.2	.05	<.03
Average	.05	.07	<.2	<.2	.07	.06

[a] Due to a change in counting equipment, the minimum detectable activity for January, February, May, and June was 0.03 pCi/m³ ±10 percent error at the 95-percent confidence level. During March and April, the minimum detectable activity was 0.02 pCi/m³ ±50 percent error at the 95-percent confidence level.

[b] Average not calculated for less than five samples.

NS, no sample.

REFERENCES

(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(*6*) INSTITUTO NACIONAL DE ENERGIA NUCLEAR. Mexican air monitoring program, August-December 1970 and January 1971. Radiol Health Data Rep 12:525-528 (October 1971).

(*7*) VASQUEZ, M. and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la Republica Mexicana, 1963-1965. Comision Nacional de Energía Nuclear, Direccion General de Seguridad Radiológica (1966).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors annual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual." [1]

Summaries of the environmental radioactivity data follow for the National Reactor Testing Station and the Oak Ridge Area.

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[1] Title 10, Code to Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. National Reactor Testing Station[2]
January–December 1970

Health Services Laboratory
U.S. Atomic Energy Commission
Idaho Falls, Idaho

The National Reactor Testing Station (NRTS) was established in 1949 by the U.S. Atomic Energy Commission (AEC) to promote reactor development by building, testing, and operating various types of nuclear reactors, allied plants, and equipment. By 1970, 49 reactors had been built at the NRTS and 16 were still operating or operable.

The NRTS is situated on a desert plain in southeastern Idaho at an average elevation of 4,865 feet. The station is comprised of 571,800 acres of sagebrush and basalt fields and the boundary stretches 39 miles from north to south and about 36 miles wide in its broader southern part. The nearest NRTS boundaries are 29 miles west of Idaho Falls, 32 miles northwest of Blackfoot, 50 miles northwest of Pocatello, and 7 miles southeast of Arco, Idaho (figure 1).

Although annual precipitation in the NRTS areas has averaged only 8.5 inches, underlying the desert plain is a huge natural underground reservoir of water in the basaltic lava rock. The lateral flow of this water is about one billion gallons per day. Aquifer water is supplied principally from the North Fork of the Snake River. Additional water comes from the Big and Little Lost Rivers and Birch Creek, which start in the mountains to the north and sink into the porous soils of the NRTS area. The underground water seeps slowly at a rate of 10-20 feet per day to the south and west, emerging in numerous springs along the Snake River between Milner and Bliss, Idaho.

Major programs currently underway at the NRTS fall into five major categories. One program provides test irradiation services from

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[2] Summarized from "National Reactor Testing Station, Environmental Monitoring Program Report" January–December 1970. U.S. Atomic Energy Commission, Idaho Operations Office, Health Services Laboratory.

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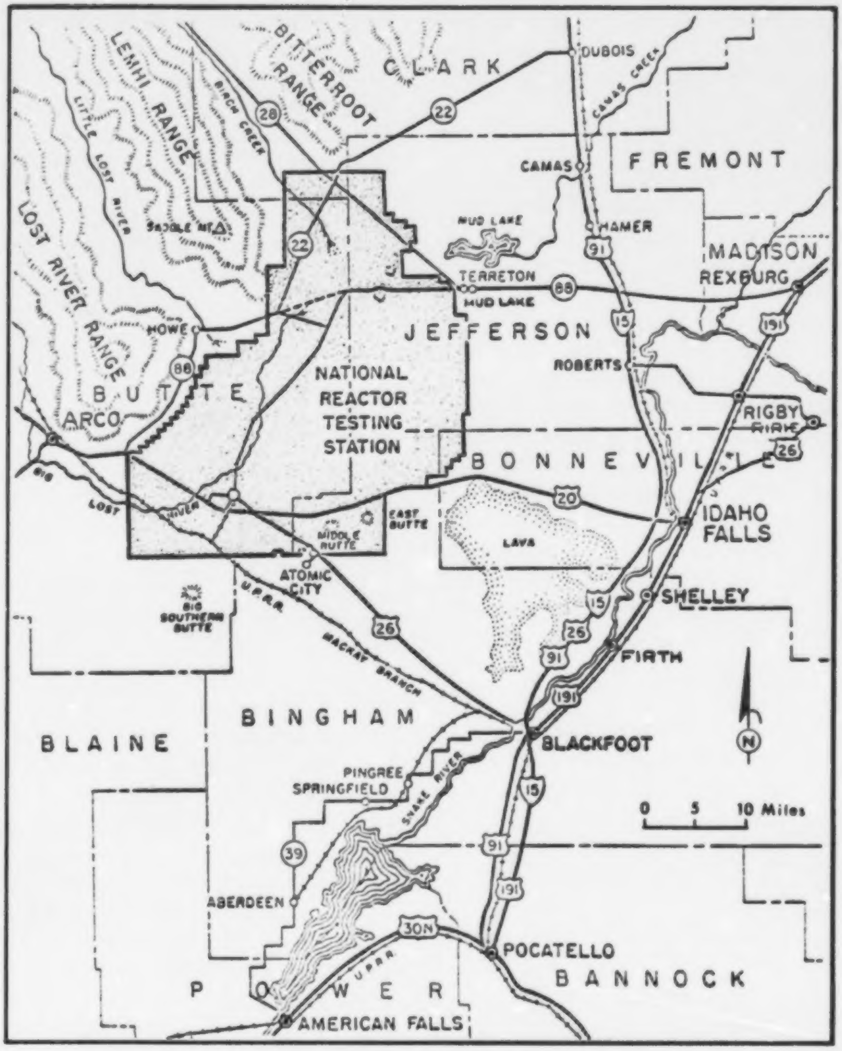

BITTERROOT RANGE
CLARK
LEMHI RANGE
LITTLE LOST RIVER
BIRCH CREEK
28
22
DUBOIS
CAMAS CREEK
CAMAS
FREMONT
LOST RIVER RANGE
SADDLE MT.
MUD LAKE
HAMER
91
MADISON
REXBURG
TERRETON
MUD LAKE
88
JEFFERSON
15
191
HOWE
ROBERTS
BUTTE
ARCO
NATIONAL REACTOR TESTING STATION
RIGBY
RIRIE
26
BONNEVILLE
20
BIG LOST RIVER
EAST BUTTE
MIDDLE BUTTE
LAVA
IDAHO FALLS
ATOMIC CITY
BIG SOUTHERN BUTTE
U.P.R.R.
SHELLEY
MACKAY BRANCH
FIRTH
BINGHAM
BLAINE
BLACKFOOT
N
PINGREE
SPRINGFIELD
SNAKE RIVER
0 5 10 Miles
39
ABERDEEN
30N
POCATELLO
BANNOCK
P O W E R
AMERICAN FALLS

Figure 1. National Reactor Testing Station environs

the two operating high-flux test reactors, the ETR and ATR. Another program operates the Idaho Chemical Processing Plant (ICPP) for recovery of uranium from highly enriched spent fuels. A third major program is that of light-water-cooled reactor safety testing and research. The Loss-of-Fluid Test (LOFT) and the Power Burst Facility (PBF) are the important projects in the reactor safety program. Other significant programs include the operation of the Experimental Breeder Reactor II (EBR–II) by Argonne National Laboratory and the operation of the Naval Reactor Facility (NRF).

Because of these activities, small amounts of radioactivity were released to the atmosphere and the Snake River Plain aquifer. In its environmental monitoring program, the Health Services Laboratory (HSL) of the AEC measured the levels of radioactivity in air and ground water samples and measured the gamma radiation exposure at onsite locations, communities near the NRTS boundary, and distant background locations. The concentration of suspended airborne particulates and dust fall rates also were measured.

Air monitoring

Air samplers were operated continuously and drew air through sets of filters for weekly periods. A membrane prefilter (Gelman Model VM–4) for collection of particulates was followed by an in-line activated charcoal-impregnated cellulose fiber filter (Gelman Model AC–1) for removal of radioiodine from the air stream. An average air flow of approximately 1 cubic foot per minute (cfm) was maintained. Air samplers were located onsite, in the small towns close to the NRTS perimeter, and at distant background sites (figure 2). These locations provided comprehensive surveillance of atmospheric radioactivity and theoretically made it possible to differentiate worldwide fallout from NRTS releases.

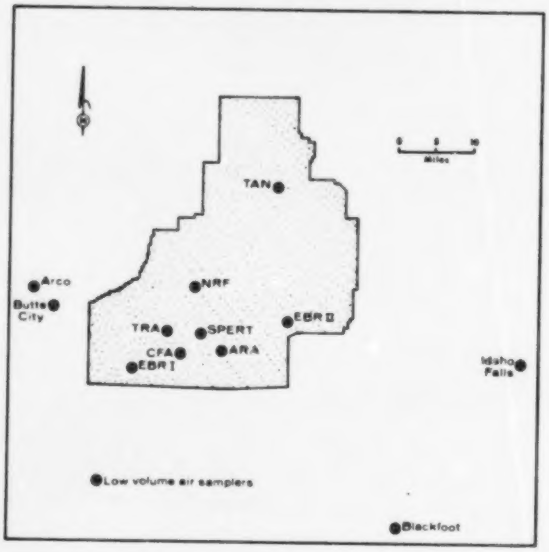


Figure 2. Onsite and offsite air sampling locations National Reactor Testing Station

The filters were analyzed 5 days after the end of each sampling period to allow for decay of short-lived natural radioactivity. Gross alpha and beta analyses were performed on the membrane filters and gross beta analyses alone were performed on the charcoal filters. Activity detected on the charcoal filters was assumed to be iodine-131. Gross alpha activity was determined by a technique reported by Hallden and Harley (*1*). Using this method, an alpha-sensitive phosphor disc was placed in direct contact with the filter and counted with a low-noise photomultiplier tube. For gross beta analyses, the filters were mounted on a ringed planchet and counted in a low background beta counter. At the end of each calendar quarter, the particulate filters from selected locations were composited and the concentrations of gamma-emitting radionuclides determined by gamma spectrometry. A strontium-90 analysis also was performed on the quarterly composites. Each membrane filter was dried and weighed before and after use to determine the average airborne particulate concentrations during the sampling period.

Onsite air samples were collected at locations close to the sources of released radioactivity and were expected to have the highest concentrations. Background samples were collected at Idaho Falls, Blackfoot, and Pocatello. These locations were sufficiently remote to ensure that any radioactivity detected was due to natural background or sources other than NRTS operations. Levels of radioactivity in onsite and boundary community (Arco and Butte City) air samples were compared to levels in the background samples. If the radioactivity levels were found to be significantly higher than background, the net amount above background was assumed to be radioactivity introduced to the environment from NRTS operations. The net concentrations of radioactivity then were compared to the AEC standards set forth in the U.S. Atomic Energy Commission's Manual Chapter 0524 (AECM 0524). The air sampling data are presented in table 1.

The gross alpha air concentrations at the background locations of Idaho Falls, Blackfoot, and Pocatello were not representative of the NRTS background levels. This was due to higher airborne concentrations of naturally occurring radioactivity in the upper Snake River Valley. Therefore, the onsite gross alpha concentrations and the gross alpha concentra-

Table 1. Radioactivity in air, National Reactor Testing Station, January-December 1970

Sampling locations	Number of samples collected	Type of analysis and filter	Minimum detectable concentration (fCi/m³)	Maximum single sample concentration (fCi/m³)	Average sample concentration (fCi/m³)	Average background concentration, if applicable (fCi/m³)	Maximum average net concentration (fCi/m³)	AEC standard (fCi/m³)	Maximum average net concentration percent of standard
Onsite (8 locations)	416	Gross alpha; membrane	1	5.6	1.8	--	1.8	6,000	0.03
		Gross beta; membrane	10	4,400	600	430	170	[a] 30,000	.57
		Gross beta; charcoal	10	40	<10	<10	<10	9×10^6	<.001
EBR-I (onsite)	52	^{144}Ce-Pr; membrane	--	--	100	60	40	6×10^6	<.001
		^{125}Sb; membrane	--	--	8.0	--	8.0	3×10^7	<.001
		^{134}Cs; membrane	--	--	5.7	.6	5.1	4×10^7	<.001
		^{137}Cs; membrane	--	--	29	7.5	21	1×10^7	<.001
		^{106}Ru-Rh; membrane	--	--	38	28	10	6×10^6	<.001
		^{95}Zr; membrane	--	--	3.4	1.7	1.7	3×10^7	<.001
		^{95}Nb; membrane	--	--	6.9	4.0	2.9	1×10^8	<.001
		^{54}Mn; membrane	--	--	.2	.5	--	4×10^7	--
		^{60}Co; membrane	--	--	2.9	--	2.9	9×10^6	<.001
		^{90}Sr; membrane	--	--	18	4	14	1×10^6	<.001
		^{103}Ru; membrane	--	--	3.4	--	3.4	8×10^7	<.001
Arco (offsite)	52	Gross alpha; membrane	1	6.2	2.0	--	2.0	20	10
		Gross beta; membrane	10	1,000	420	430	--	[a] 1,000	--
		Gross beta; charcoal	10	10	<10	<10	<10	1×10^5	<.01
Butte City (offsite)	52	Gross alpha; membrane	1	5.2	1.8	--	1.8	20	9
		Gross beta; membrane	10	1,600	500	430	70	[a] 1,000	7
		Gross beta; charcoal	10	30	<10	<10	<10	1×10^5	<.01
		^{144}Ce-Pr; membrane	--	--	79	60	19	2×10^5	.01
		^{125}Sb; membrane	--	--	5.0	--	5.0	9×10^5	<.001
		^{103}Ru; membrane	--	--	.2	--	.2	3×10^6	<.001
		^{106}Ru-Rh; membrane	--	--	24	28	--	2×10^5	--
		^{134}Cs; membrane	--	--	2.1	.6	1.5	4×10^5	<.001
		^{137}Cs; membrane	--	--	9.3	7.5	1.8	5×10^5	<.001
		^{95}Zr; membrane	--	--	3.9	1.7	2.2	1×10^6	<.001
		^{95}Nb; membrane	--	--	6.0	4.0	2.0	3×10^6	<.001
		^{54}Mn; membrane	--	--	.8	.5	.3	1×10^6	<.001
		^{90}Sr; membrane	--	--	5.2	3.9	1.3	30,000	.004

[a] Assumes actinium-227 not present.

tions at the NRTS boundary communities were not compared to an average background concentration. However, if measurable onsite releases of alpha activity were occurring, it would have been expected that the gross alpha concentrations at onsite locations would be higher than at the communities near the NRTS boundary. This pattern was not observed and indicates the gross alpha concentrations measured at the NRTS and boundary community locations were the result of natural background radioactivity.

Excluding the results from the last 2 weeks of 1970, all the gross beta (iodine-131) concentrations determined from the charcoal filters were near or below the detection limit of the analysis. For 1970, the average gross beta concentration of particulates at onsite locations was 0.6 pCi/m³ and the highest individual average was 0.8 pCi/m³, occurring at the CFA location. The yearly average background gross beta concentration was 0.44 pCi/m³. The difference between the average onsite and offsite gross beta concentration was largely the result of releases of small quantities of radioactivity from the Idaho Chemical Processing Plant. Fission and activation products identified on the onsite particulate filters were cerium-praseodymium-144, antimony-125, cesium-134, cesium-137, ruthenium-rhodium-106, ruthenium-103, zirconium-95, niobium-95, manganese-54, cobalt-60, and strontium-90. All but antimony-125, ruthenium-103, and cobalt-60, also were identified on the background air filters, though generally in smaller concentrations. None of the concentrations of radionuclides identified on the onsite filters exceeded 0.001 percent of the corresponding AEC standards.

At the air sampling locations of Butte City and Arco, the offsite sampling locations closest to the NRTS, it was found that the average gross beta concentration (at Butte City) was slightly above the worldwide fallout level. The yearly average net gross beta concentration of 0.07 pCi/m³ was only 1 percent of the appropriate concentration guide. Except for cobalt-60 the same radionuclides identified in the onsite samples also were found at Butte City, although generally in smaller concentrations. None of the net concentrations of radionuclides identified on the Butte City filters exceeded 0.01 percent of the concentration guide.

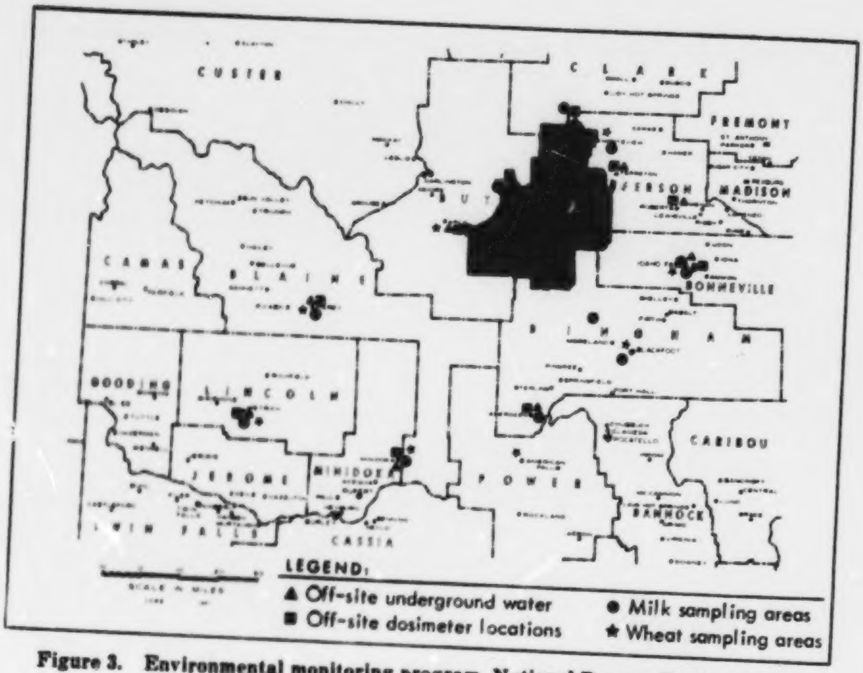

CUSTER
CLARK
FREMONT
MADISON
BUTTE
CAMAS
BLAINE
BONNEVILLE
BINGHAM
GOODING
LINCOLN
JEROME
MINIDOKA
CARIBOU
POWER
BANNOCK
TWIN FALLS
CASSIA
SCALE IN MILES
LEGEND:
▲ Off-site underground water
■ Off-site dosimeter locations
● Milk sampling areas
★ Wheat sampling areas

Figure 3. Environmental monitoring program, National Reactor Testing Station

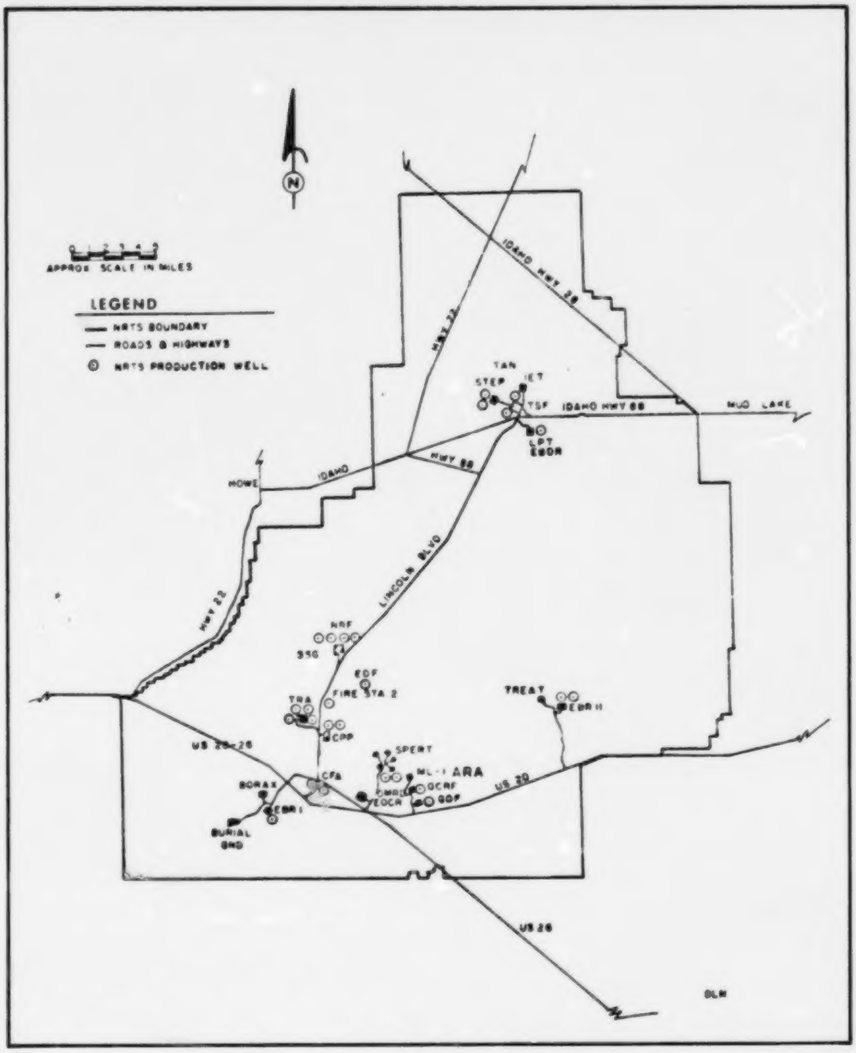
Water monitoring

Water samples were collected from onsite and offsite drinking water production wells and from the Snake River. Offsite and onsite water sampling locations can be seen in figures 3 and 4, respectively. All offsite samples were collected biannually; generally onsite samples were collected every 2 weeks. Gross alpha, gross beta, and tritium analyses routinely were performed on the water samples. For gross alpha analysis, an aliquot of the sample was evaporated on a stainless-steel planchet and counted with a scintillation counter using a technique similar to that described for the gross alpha analysis for the air filters. Another aliquot was evaporated and counted for gross beta activity in a low background beta counter. Tritium concentrations were determined with a Beckman liquid scintillation system. Water sampling data are presented in tables 2 and 3. Samples collected from Mud Lake, Monteview, Reno Ranch, Idaho Falls, and Roberts (all upgradient in the aquifer from the NRTS) were used to determine the background concentrations of radioactivity.

None of the offsite water samples collected during 1970 contained concentrations of radioactivity above the detection limits of the analyses. Only a few onsite samples contained gross alpha concentrations above the detection limit of 3 pCi/liter. The highest average beta concentration, 49 pCi/liter, was found in well number 1 at the Idaho Chemical Processing Plant. This well was used only during the first half of 1970. During the second half of the year, ICPP well number 2 had an average gross beta concentration of 16 pCi/liter. The 1970 average strontium-90 concentrations were 16 pCi/liter and 3.1 pCi/liter for ICPP wells number 1 and number 2, respectively. These strontium-90 concentrations are less than 2 percent of the AECM 0524 standard. The highest 1970 average tritium concentration, 100 nCi/liter was found in well number 1 at the Central Facilities Area (CFA) and was 3 percent of the AECM 0524 standard.

Food monitoring

Milk was the main foodstuff sampled. A composite grade A sample was collected from farm areas to the north and south of Idaho Falls


N
0 1 2 3 4 5
APPROX SCALE IN MILES
LEGEND
NRTS BOUNDARY
ROADS & HIGHWAYS
NRTS PRODUCTION WELL
IDAHO HWY 28
HWY 22
TAN
STEP
IET
TSF
IDAHO HWY 88
MUD LAKE
LPT
EBOR
HOWE
IDAHO
HWY 88
LINCOLN BLVD
HWY 22
NRF
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FIRE STA 2
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TREAT
EBR II
US 20-26
SPERT
ML-1
ARA
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EBR I
OMRE
EOCR
GCRF
GDF
US 20
BURIAL GND
US 26
BLM

Figure 4. National Reactor Testing Station

each week. Monthly grade B milk samples were collected from dairies and individual farms in rural areas surrounding the NRTS. Analysis by gamma spectrometry for iodine-131 and cesium-137 was performed on all milk samples. Biannually the samples were analyzed for strontium-90. Wheat samples were collected from individual farms and grain elevators during the fall harvest and analyzed for gamma-emitting radionuclides by gamma spectrometry and for strontium-90. See figure 3 for the milk and wheat sampling locations.

All milk sampling results summarized in table 4 were compared to standards recommended by the Federal Radiation Council, since the AECM 0524 does not list concentration guides for milk. Neither iodine-131 nor cesium-137 was detected in any milk sample collected during 1970. Strontium-90 concentrations in milk were less than 2 percent of the standard.

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Table 2. Radioactivity in well water samples, National Reactor Testing Station, January-December 1970

Sampling locations	Number of samples collected	Type of analysis	Maximum single sample concentration (pCi/liter)	Minimum detectable concentration (pCi/liter)	Average sample concentration (pCi/liter)	Average background concentration (pCi/liter)	Maximum average net concentration (pCi/liter)	Maximum average net concentration percent of standard
EBR-I (1 well)	24	Gross alpha	3.3	3	<3.0	<3	<3	<10
		Gross beta	7.3	5	<5.0	<5	<5.0	<17
		Tritium	[b] <2	[b] 2	[b] <2	[b] <2	[b] <2	<0.7
CFA (2 wells)	24	Gross alpha	<3	3	<3	<3	<30	<10
		Gross beta	9.1	5	<5.2	<5	<5.2	<17
		Tritium	[b] 180	[b] 2	[b] 78	[b] <2	[b] 78	2.6
TRA (3 wells)	29	Gross alpha	8.0	3	<3.0	<3	<3.0	<10
		Gross beta	<5	5	<5	<5	<5	<17
		Tritium	[b] <2	[b] 2	[b] <2	[b] <2	[b] <2	<.07
CPP (2 wells)	68	Gross alpha	5.6	3	<3.1	<3	<3.1	<10
		Gross beta	65	5	24	<5	24	80
		Tritium	[b] 280	[b] 2	[b] 48	[b] <2	[b] 48	1.6
		Strontium-90	10	1	3.1		3.1	1.0
NRF (3 wells)	64	Gross alpha	<3	3	<3	<3	<3	<10
		Gross beta	9.5	5	<5.2	<5	<5.2	<17
		Tritium	[b] <2	[b] 2	[b] <2	[b] <2	[b] <2	<.07
TAN (5 wells)	120	Gross alpha	23	3	<3.2	<3	<3.2	<11
		Gross beta	20	5	<5.3	<5	<5.3	<18
		Tritium	[b] <2	[b] 2	[b] <2	<2	[b] <2	<.07
SPERT-PBF (2 wells)	36	Gross alpha	6.5	3	<3.1	<3	<3.1	<10
		Gross beta	<5	5	<5	<5	<5	<17
		Tritium	[b] <2	[b] 2	[b] <2	[b] <2	[b] <2	<.07
ARA (2 wells)	48	Gross alpha	5	3	<3.0	<3	<3.0	<10
		Gross beta	<5	5	<5	<5	<5	<17
		Tritium	[b] <2	[b] 2	[b] <2	[b] <2	[b] <2	<.07
EDF (1 well)	12	Gross alpha	<3	3	<3	<3	<3	<10
		Gross beta	5.9	5	<5.0	<5	<5.0	<17
		Tritium	[b] <2	[b] 2	[b] <2	[b] <2	[b] <2	<.07
EBR-II (2 wells)	30	Gross alpha	6.5	3	<3.2	<3	<3.2	<11
		Gross beta	5	5	<5	<5	<5	<17
		Tritium	[b] <2	[b] 2	[b] <2	[b] <2	[b] <2	<.07
Fire station #2 (1 well)	24	Gross alpha	5.5	3	<3.1	<3	<3.1	<10
		Gross beta	5.8	5	<5.0	<5	<5.0	<17
		Tritium	[b] <2	[b] 2	[b] <2	[b] <2	[b] <2	<.07

[a] AEC standards—gross alpha, 30 pCi/liter; gross beta, 30 pCi/liter; tritium, 3,000 pCi/liter, and strontium-90, 300 pCi/liter.
[b] Concentration of tritium in nCi/liter.

Table 3. Radioactivity in offsite drinking water and surface water samples, National Reactor Testing Station January-December 1970

Sampling locations	Number of samples collected	Type of analysis	Maximum single sample concentration (pCi/liter)	Minimum detectable concentration (pCi/liter)	Average sample concentration (pCi/liter)	Average background concentration if applicable (pCi/liter)	Maximum average net concentration (pCi/liter)	Maximum average net concentration percent of standard[a]
Drinking water, from Arco, Carey, Aberdeen, Dietrich, Atomic City, and Minidoka	12	Gross alpha	<3	3	<3	<3	<3	<10
		Gross beta	5	5	<5	<5	<5	<17
		Tritium	[b] <2	[b] 2	[b] <2	[b] <2	[b] <2	<.07
Snake River at Bliss, Idaho	2	Gross alpha	<3	3	<3	<3	<3	<10
		Gross beta	<5	5	<5	<5	<5	<17
		Tritium	[b] <2	[b] 2	[b] <2	[b] <2	[b] <2	<.07

[a] AEC standard—gross alpha, 30 pCi/liter; gross beta, 30 pCi/liter; tritium, 3,000 nCi/liter.
[b] Concentration of tritium in nCi/liter.

The strontium-90 concentrations were similar to those reported in *Radiological Health Data and Reports* for this region of the country and the source is believed to be fallout from nuclear weapons and not NRTS operations. Only strontium-90 activity was detected in the wheat samples with the hull containing 90 percent of the total. This means only 10 percent of the activity will remain after the wheat is processed for use in food products. The strontium-90 in wheat also is attributed to worldwide fallout. Wheat sampling results are shown in table 5.

Table 4. Radionuclide concentrations in milk, National Reactor Testing Station, January-December 1970

Location and sampling frequency	Analysis	Maximum single sample concentration (pCi/liter)	Average sample concentration (pCi/liter)	Average concentration percent of standard[a]
Idaho Falls (weekly)	Iodine-131	<20	<20	<20
	Cesium-137	<30	<30	<.8
	Strontium-90[b]	9.4	6.2	3.1
Minidoka (monthly)	Iodine-131	<20	<20	<20
	Cesium-137	<30	<30	<.8
	Strontium-90[b]	4	2.8	1.4
Dietrich (monthly)	Iodine-131	<20	<20	<20
	Cesium-137	<30	<30	<.8
	Strontium-90[b]	4	3.4	1.7
Carey (monthly)	Iodine-131	<20	<20	<20
	Cesium-137	<30	<30	<.8
	Strontium-90[b]	3	2.8	1.4
Mud Lake (monthly)	Iodine-131	<20	<20	<20
	Cesium-137	<30	<30	<.8
	Strontium-90[b]	3.6	3.3	1.7
Reno Ranch (monthly)	Iodine-131	<20	<20	<20
	Cesium-137	<30	<30	<.8
	Strontium-90[c]	1.2	1.2	.6
Tabor (monthly)	Iodine-131	<20	<20	<20
	Cesium-137	<30	<30	<.8
	Strontium-90[b]	3	2.5	1.3
Howe (monthly)	Iodine-131	<20	<20	<20
	Cesium-137	<30	<30	<.8
	Strontium-90[b]	4.5	4.2	2.1
Arco (monthly)	Iodine-131	<20	<20	<20
	Cesium-137	<30	<30	<.8
	Strontium-90[b]	3.5	2.2	1.1
Firth and New Sweden (near Idaho Falls) (monthly)	Iodine-131	<20	<20	<20
	Cesium-137	<30	<30	<.8
	Strontium-90[b]	3.4	3.2	1.6
Lake and Riverside (Tabor-Blackfoot-Aberdeen area, monthly)	Iodine-131	<20	<20	<20
	Cesium-137	<30	<30	<.8
	Strontium-90[b]	3	2.3	1.2

[a] Federal Radiation Council standard: iodine-131, 100 pCi/liter; cesium-137, 3,600 pCi/liter; strontium-90, 200 pCi/liter.

[b] Only two samples during the year were analyzed for strontium-90 activity.

[c] Only one sample during the year was analyzed for strontium-90 activity.

Table 5. Strontium-90 concentrations in wheat National Reactor Testing Station, January-December 1970

Sampling location	Strontium-90 concentration (pCi/g)
Monteview	0.021
Idaho Falls	.014
Blackfoot	.01
American Falls	.014
Minidoka	.016
Dietrich	.009
Carey	.013
Arco	.0046

Table 6. Gamma radiation monitoring data National Reactor Testing Station, January-December 1970

Location	Exposure (mR)	
	May-November 1970	November 1969-November 1970
Background locations:		
Idaho Falls AEC headquarters	48.5	[a] 48.5—64.6
Idaho Falls Airport	37.9	57.7
Blackfoot	51.2	[a] 51.2—65.1
Carey	<13	<29
Dietrich	26.2	([b])
Aberdeen	34.9	[a] 34.9—55.9
Minidoka	20.0	30.7
NRTS perimeter locations:		
Arco	34.9	49.8
Butte City	39.9	[a] 39.9—61.7
Mud Lake	26.4	42.8
Howe	34.2	47.8
Atomic City	38.4	69.6
Roberts	43.3	60.8

[a] A range is reported when the exposure from November 1969 to May 1970 was below the detection limit. The lower value assumes the exposure was zero during this period; the high value assumes the exposure was equal to the detection limit and is the maximum possible yearly exposure.

[b] No data available for the November 1969 to May 1970 exposure period.

Gamma radiation exposure

Environmental gamma radiation exposures were measured with thermoluminescent dosimeters (TLDs) placed at both onsite and offsite locations. The exposures reported in table 6 were the amounts greater than those received by a control group of dosimeters placed in a lead shield in the laboratory. Thus, the reported exposures do not include all the exposure which results from natural background. Exposures at the distant locations of Idaho Falls, Blackfoot, Dietrich, Carey, Aberdeen, and Minidoka were considered background levels. Because of the unusually low exposure at Carey, the results at that location are questionable. The maximum exposure at the boundary communities of Atomic City, Howe, Arco, Butte City, Mud Lake, and Roberts was 62 mR at Butte City for the period, November 1969 to November 1970. The highest exposure at a background location during the same period was 65 mR at Blackfoot. There was no evidence that any of the offsite exposures were the result of NRTS activities.

Summary

The results of the air monitoring program for 1970 indicated that any increases in offsite air concentrations due to NRTS releases were indistiguishable from the natural radioactivity in air. When special techniques were used to measure the worldwide radioactive fallout (approximately 0.2 percent to 2 percent of the natural radioactivity in air), the sensitivity was high enough to indicate small releases of NRTS activity measurable above the worldwide fallout. The average increased exposure by airborne radioactivity just offsite was approximately 0.5 percent of the natural radon series and thoron series exposure in air. From identification of specific radionuclide concentrations it was found that none of the concentrations was greater than 0.01 percent of the appropriate standard listed in AECM 0524.

None of the offsite well water or surface water samples contained any gross alpha, gross beta, or tritium activity above the detection limits of the analyses. The only fission or activation product detected in milk samples was strontium-90. These concentrations were similar to those reported in *Radiological Health Data and Reports* for the region and the source is believed to be fallout from nuclear weapons and not NRTS operations. Wheat samples collected at harvest also contained small amounts of strontium-90 from worldwide fallout.

Gamma radiation exposures were measured simultaneously at distant background locations and at communities near the NRTS boundary. There was no evidence that the exposures at the NRTS boundary communities were different from background.

REFERENCE

(*1*) HALLDEN and HARLEY. An improved alpha counting technique. Anal Chem 32:1861 (1960).

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2. Oak Ridge Area[3]
July–December 1970

Union Carbide Nuclear Company
Oak Ridge, Tenn.

Oak Ridge area is a complex made up primarily of the Y-12 Plant, the Oak Ridge National Laboratory (ORNL), and the Oak Ridge Gaseous Diffusion Plant (ORGDP).

Radioactive waste materials arising from the operation of atomic energy installations in the Oak Ridge area are collected, treated, and disposed of according to their physical states. Solid wastes are buried in a Conasauga shale formation [illegible] marked ability to fix ra[illegible] exchange mechanism[illegible] which contain long-lived fission products are confined in storage tanks or are concentrated by evaporation and disposed of in deep wells. Low-level liquid wastes are discharged, after preliminary treatment, to the surface streams. Air that may become contaminated by radioactive materials is exhausted to the atmosphere from several tall stacks after treatment by means of scrubbers and filters.

Air monitoring

Atmospheric contamination by radioactive

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[3] Summarized from Environmental Levels of Radioactivity for the Oak Ridge area, (Report Period, July–December 1970). Health Physics and Safety Section, Health Physics Division, Oak Ridge National Laboratory.

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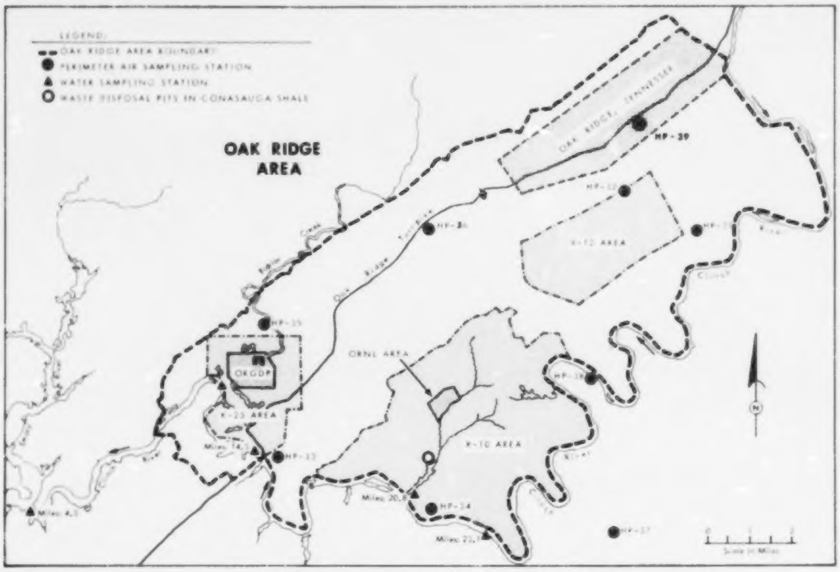
LEGEND:
OAK RIDGE AREA BOUNDARY
PERIMETER AIR SAMPLING STATION
WATER SAMPLING STATION
WASTE DISPOSAL PITS IN CONASAUGA SHALE
OAK RIDGE AREA
OAK RIDGE, TENNESSEE
HP-39
HP-32
HP-31
HP-36
Y-12 AREA
HP-35
ORGDP
K-25 AREA
Oak Ridge Turnpike
ORNL AREA
X-10 AREA
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Figure 5. Oak Ridge Area environmental sampling locations

materials occurring in the general environment of East Tennessee is monitored by two systems of monitoring stations. One system consists of nine stations which encircle the plant areas (figure 5) and provide data for evaluating the impact of all Oak Ridge operations on the immediate environment. A second system consists of eight stations encircling the Oak Ridge area at distances of from 12 to 75 miles (figure 6). This system provides data to aid in evaluating local conditions and to assist in determining the spread or dispersal of contamination should a major incident occur.

Sampling for radioactive particulates is carried out by passing air continuously through a filter paper. Average radioactivity concentrations are presented in tables 7 and 8. Airborne radioactive iodine is sampled in the immediate environment of the plant areas by passing air through a cartridge containing activated charcoal.

During the July-December 1970 surveillance period, 234 samples were collected from perimeter monitoring stations and analyzed for iodine-131. Of these, the maximum concentration detected was 0.037 pCi/m^3, the minimum was less than 0.01 pCi/m^3 and the average was 0.01 pCi/m^3. The radiation protection standard specified in the AEC manual for iodine-131 in the ambient atmosphere in uncontrolled areas is 100 pCi/m^3.

Milk monitoring

Raw milk is monitored for iodine-131 and strontium-90 by the collection and analysis of samples from 12 sampling stations located within a radius of 50 miles of ORNL. Samples are collected weekly at each of eight stations located on the fringe of the Oak Ridge area. Four stations, located more remotely with respect to the Oak Ridge operations, are sampled at a rate of one station each week. The purpose of the milk sampling program is twofold: first, samples collected in the immediate vicinity of the Oak Ridge area provide data by which one may evaluate possible exposure to the neighboring population resulting from waste releases from Oak Ridge operations; second, samples collected at the more remote stations provide background data which are essential in establishing the proper index for the evaluation of data obtained from local samples. The concentrations of iodine-131 and strontium-90 detected in raw milk samples during the period are given in table 9.

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Table 7. Long-lived gross beta radioactivity of particulates in air, Oak Ridge Area, July-December 1970

Perimeter stations						Remote stations					
Station number (figure 5)	Number of samples	Concentration (fCi/m³)			Percent of AEC standard[a]	Station number (figure 6)	Number of samples	Concentration (fCi/m³)			Percent of AEC standard[a]
		Maximum	Minimum	Average				Maximum	Minimum	Average	
HP-31	26	440	29	150	0.15	HP-51	26	490	54	170	0.17
HP-32	26	540	34	190	.19	HP-52	26	620	42	200	.20
HP-33	26	380	57	150	.15	HP-53	26	560	43	210	.21
HP-34	26	490	24	170	.17	HP-54	26	560	6	190	.19
HP-35	26	500	21	180	.18	HP-55	26	610	46	220	.22
HP-36	[b] 123	540	37	220	.22	HP-56	26	490	45	170	.17
HP-37	26	430	[illegible]	150	.15	HP-57	26	420	58	150	.15
HP-38	26	480	59	190	.19	HP-58	24	570	18	210	.21
HP-39	26	580	23	180	.18						
Summary	331	580	21	170	0.17	Summary	206	620	6	190	0.19

[a] The applicable AEC radiation protection standard is 100 pCi/m³.
[b] Sample frequency—5 days per week.

Table 8. Long-lived gross alpha radioactivity of particulates in air, Oak Ridge Area, July-December 1970

Perimeter stations						Remote stations					
Station number (figure 5)	Number of samples	Concentration (pCi/m³)			Percent of AEC standard[a]	Station number (figure 6)	Number of samples	Concentration (pCi/m³)			Percent of AEC standard[a]
		Maximum	Minimum	Average				Maximum	Minimum	Average	
HP-31	26	3	<1	1	0.05	HP-51	26	8	<1	1	0.05
HP-32	26	5	<1	2	.10	HP-52	26	5	<1	2	.10
HP-33	26	3	<1	1	.05	HP-53	26	5	<1	1	.05
HP-34	26	4	<1	1	.05	HP-54	26	8	<1	1	.05
HP-35	26	8	<1	1	.05	HP-55	26	4	<1	1	.05
HP-36	123	10	<1	5	.25	HP-56	26	5	<1	1	.05
HP-37	26	2	<1	<1	<.05	HP-57	26	3	<1	1	.05
HP-38	26	5	<1	1	.05	HP-58	24	6	<1	2	.10
HP-39	26	6	<1	1	.05						
Summary	331	10	<1	2	0.10	Summary	206	8	<1	1	0.05

[a] The applicable AEC radiation protection standard for natural uranium in air is 2 pCi/m³.
[b] Sampling frequency—5 days per week.

Table 9. Radionuclides in raw milk, Oak Ridge area July-December 1970

Radionuclide and location	Concentration (pCi/liter)		
	Maximum	Minimum[a]	Average
Iodine-131			
Immediate environs	22	<10	<10
Remote environs	11	<10	<10
Strontium-90			
Immediate environs	25	2.0	11.6
Remote environs	13	2.0	8.4

[a] The minimum detectable concentrations of iodine-131 and strontium-90 in milk are 10 pCi/liter and 2 pCi/liter, respectively. In averaging, one-half of the minimum detectable concentration was used for all samples showing an activity less than this concentration.

Water monitoring

Large volume, low-level liquid wastes originating at ORNL are discharged, after some preliminary treatment, into the Tennessee River system by way of White Oak Creek and the Clinch River. Liquid wastes originating at the ORGDP and Y-12 Plant are discharged to Poplar Creek and thence to the Clinch River. Releases are controlled so that resulting average concentrations in the Clinch River comply with AEC radiation protection standards. The radioactivity concentration from White Oak Creek is measured, and concentration values for the Clinch River are calculated on the basis of the dilution provided by the river.

Water samples are taken at a number of locations in the Clinch River, beginning at a point above the entry of wastes into the river and ending at Center's Ferry near Kingston, Tenn. Stream gauging operations are carried on continuously to obtain dilution factors for calculating the probable concentrations of

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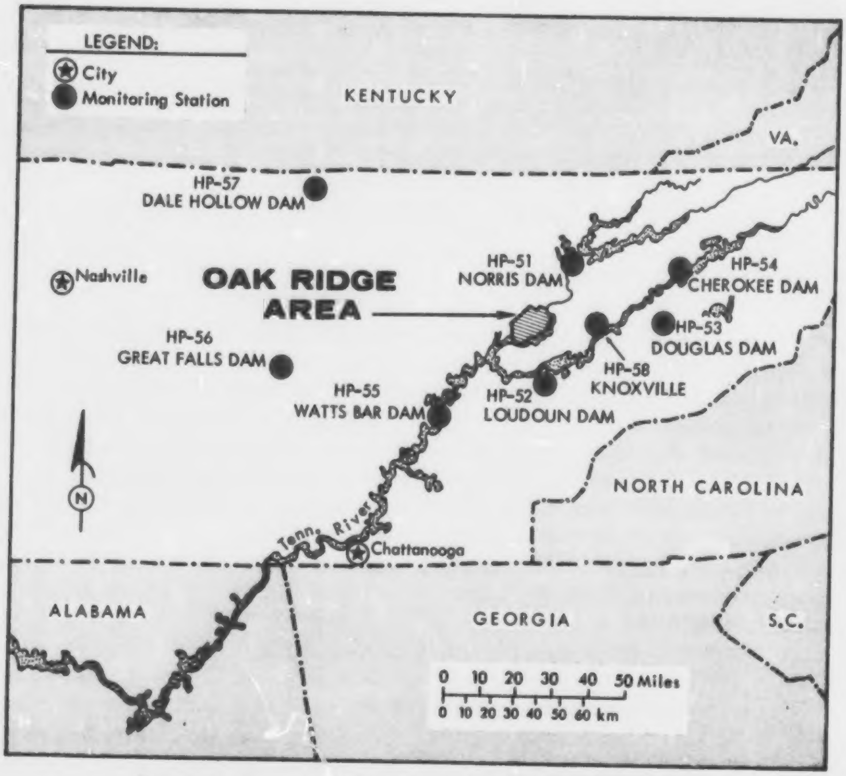
LEGEND:
City
Monitoring Station
KENTUCKY
VA.
HP-57
DALE HOLLOW DAM
Nashville
OAK RIDGE
AREA
HP-51
NORRIS DAM
HP-54
CHEROKEE DAM
HP-53
DOUGLAS DAM
HP-56
GREAT FALLS DAM
HP-58
KNOXVILLE
HP-55
WATTS BAR DAM
HP-52
LOUDOUN DAM
N
NORTH CAROLINA
Tenn. River
Chattanooga
ALABAMA
GEORGIA
S.C.
0 10 20 30 40 50 Miles
0 10 20 30 40 50 60 km

Figure 6. Remote air monitoring stations, Oak Ridge area

wastes in the river. Samples are analyzed for the long-lived beta-particle emitters, uranium, and the transuranic alpha-particle emitters. The average concentrations of major radionuclides in the Clinch River are given in table 10 for the period from July–December 1970.

Table 10. Concentrations of major radionuclides in the Clinch River, July-December 1970

Radionuclide	Average concentration (pCi/liter)			
	Location on Clinch River[a]			
	Mile 23.1 (Upstream)	Mile 20.8[b] (Outfall)	Mile 14.5 (Downstream)	Mile 4.5 (Downstream)
Strontium-90	0.4	0.5	1.4	0.8
Cerium-144	.2	<.1	.8	.3
Cesium-137	.2	.1	1.4	.9
Ruthenium-103-106	.4	.2	.5	.6
Cobalt-60	.2	<.1	.7	.3
Zirconium-niobium-95	.1	<.1	<.1	<.1
Tritium	560	980	1,080	1,880

[a] The location on Clinch River is given in terms of the distance upstream from the Tennessee River (figure 5).

[b] The concentrations at mile 20.8 are not measured directly but the values are calculated based on the levels of waste released from White Oak dam and the dilution provided by the Clinch River.

Two quarterly composite water samples from the Clinch River were analyzed for uranium during this period. For these samples, the uranium concentrations were less than 1 pCi/liter, the level of detectability. The AEC radiation protection standard for natural uranium in water released to unrestricted areas is 20 nCi/liter.

Gamma measurements

External gamma radiation levels are measured monthly at a number of locations in the Oak Ridge area. Measurements are taken with a Geiger-Mueller tube at a distance of 3 feet above the ground. The results are shown in table 11.

Discussion of data

The average air contamination levels for gross beta radioactivity, as shown by the continuous air monitoring filter data, for both the

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Table 11. External gamma radiation levels, Oak Ridge area, July-Decembe

Station	Exposure (mR/h)						
	July	August	September	October	November	December	Average
Kerr Hollow Gate	0.010	0.016	0.010	0.014	0.012	(b)	0.012
Y-12, East Portal	.008	.012	.012	.013	.011	(b)	.011
Newcomb Road	.011	.012	.011	.012	.009	(b)	.011
Gallaher Gate	.009	.010	.010	.014	.012	(b)	.011
White Wing Gate	.012	.010	.011	.012	.010	(b)	.011

[a] These readings were taken with a calibrated Geiger-Müller tube at a distance of 3 feet above the ground.
[b] Background not taken.

immediate and remote environs of the plants (figures 5 and 6) were 0.17 percent and 0.19 percent, respectively, of the AEC radiation protection standard for uncontrolled areas.

The average air contamination levels for gross alpha radioactivity, as shown by the continuous air monitoring filter data, for the immediate and remote environs of the plants were 0.10 percent and 0.05 percent, respectively, of the AEC radiation protection standard for natural uranium for uncontrolled areas.

The average concentration of iodine-131 in air in the immediate environs of the plants was 0.01 pCi/m³. This is approximately 0.01 percent of the AEC radiation standard for uncontrolled areas.

The average concentrations of iodine-131 in raw milk in the immediate and remote environs of the Oak Ridge area were both less than 10 pCi/liter. These levels fall within the limits of FRC Range I if the average intake per individual is assumed to be 1 liter of milk per day.

The average concentrations of strontium-90 in raw milk in both the immediate and remote environs of the controlled areas was 11.6 pCi/liter and 8.4 pCi/liter, respectively. The average falls within the limits of FRC Range I for transient rates of daily intake of strontium-90 for application to the average of suitable samples of an exposed population.

The percent maximum concentration of radioactivity in the Clinch River at all points of measurements were less than 1 percent of the AEC radiation protection standards. The average concentration of transuranic alpha-particle emitters in the Clinch River at mile 20.8 was 0.01 pCi/liter which is 0.01 percent of the AEC radiation protection standard for water containing a mixture of unknown radionuclides.

The average concentration of natural uranium materials in the Clinch River reflecting the effects of all Oak Ridge plants was less than 0.1 percent of the AEC radiation standard for uranium.

The average external gamma radiation measured in the town of Oak Ridge and at the perimeter of the Oak Ridge area was 0.011 mR/h, which is approximately the same as that level measured during the period prior to Oak Ridge operations.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1970	November 1971

Erratum

An error occurred in the Knolls Atomic Power Laboratory article on page 390 in the June 1973 issue. The third sentence in the second paragraph under "Effluent monitoring" should read:

"The total airborne particulate radioactivity discharged to the environment during the calendar year 1971 was less than 2 mCi."

Please make this change in your issues.

Nuclear Power Reactors in the United States
September 30, 1973

Each quarter year, the Atomic Energy Commission releases information on the status of all present and proposed civilian nuclear power generating units in the United States. This information is reproduced for interested readers of *Radiation Data and Reports.*

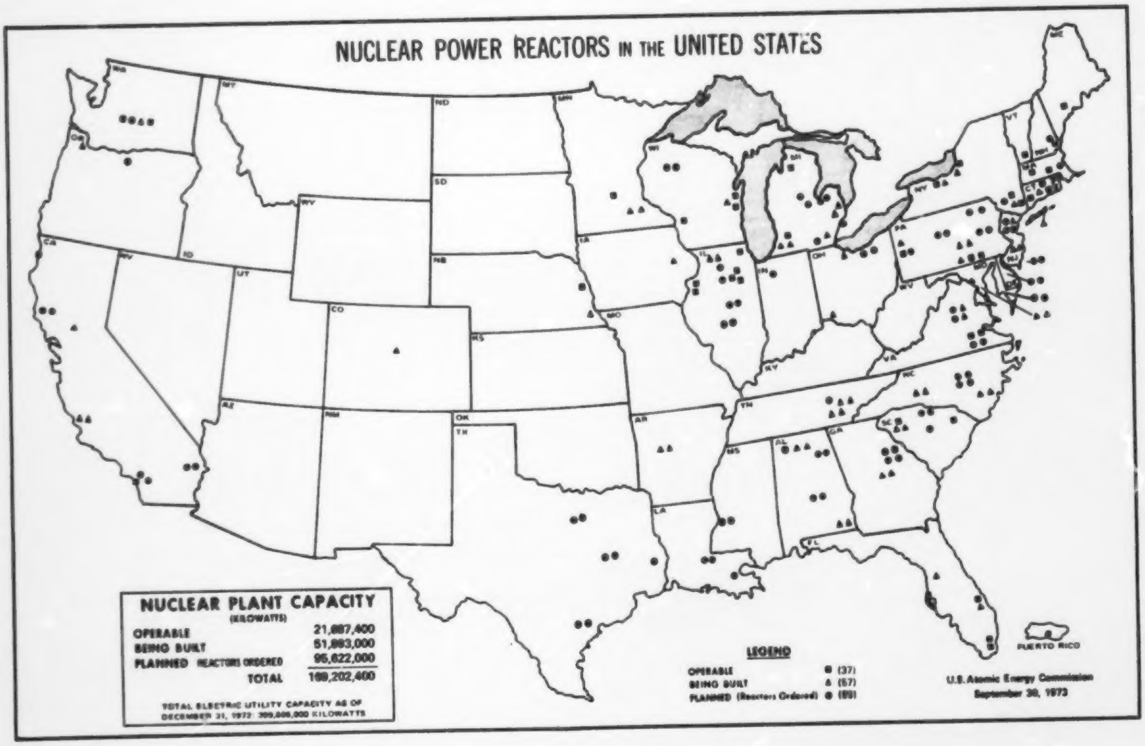
NUCLEAR POWER REACTORS IN THE UNITED STATES
NUCLEAR PLANT CAPACITY
(KILOWATTS)
OPERABLE 21,887,400
BEING BUILT 51,693,000
PLANNED REACTORS ORDERED 95,622,000
TOTAL 169,202,400
TOTAL ELECTRIC UTILITY CAPACITY AS OF DECEMBER 31, 1972: 399,606,000 KILOWATTS
LEGEND
OPERABLE ● (37)
BEING BUILT ▲ (57)
PLANNED (Reactors Ordered) ●
PUERTO RICO
U.S. Atomic Energy Commission
September 30, 1973

Figure 1. Nuclear power reactors in the United States, September 30, 1973

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	COMMERCIAL OPERATION
ALABAMA				
Decatur	Browns Ferry Nuclear Power Plant: Unit 1	1,065,000	Tennessee Valley Authority	1973
Decatur	Browns Ferry Nuclear Power Plant: Unit 2	1,065,000	Tennessee Valley Authority	1974
Decatur	Browns Ferry Nuclear Power Plant: Unit 3	1,065,000	Tennessee Valley Authority	1974
Dothan	Joseph M. Farley Nuclear Plant: Unit 1	829,000	Alabama Power Co.	1975
Dothan	Joseph M. Farley Nuclear Plant: Unit 2	829,000	Alabama Power Co.	1977
Orville	Central Alabama Nuclear Plant	1,100,000	Alabama Power Co.	1980
Orville	Central Alabama Nuclear Plant	1,100,000	Alabama Power Co.	1981
Scottsboro	Bellefonte Nuclear Plant: Unit 1	1,189,000	Tennessee Valley Authority	1979
Scottsboro	Bellefonte Nuclear Plant: Unit 2	1,189,000	Tennessee Valley Authority	1980
ARKANSAS				
Russellville	Arkansas Nuclear One: Unit 1	850,000	Arkansas Power & Light Co.	1973
Russellville	Arkansas Nuclear One: Unit 2	902,000	Arkansas Power & Light Co.	1976
CALIFORNIA				
Humboldt Bay	Humboldt Bay Power Plant: Unit 3	68,500	Pacific Gas and Electric Co.	1963
San Clemente	San Onofre Nuclear Generating Station: Unit 1	430,000	So. Calif. Ed. & San Diego Gas & El. Co.	1968
San Clemente	San Onofre Nuclear Generating Station: Unit 2	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	1978
San Clemente	San Onofre Nuclear Generating Station: Unit 3	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	1979
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 1	1,060,000	Pacific Gas and Electric Co.	1975
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 2	1,060,000	Pacific Gas and Electric Co.	1976
Clay Station	Rancho Seco Nuclear Generating Station	913,000	Sacramento Municipal Utility District	1974
•	–	1,128,000	Pacific Gas & Electric Co.	1981
•	–	1,128,000	Pacific Gas & Electric Co.	1982
•	Eastern Desert Plant: Unit 1	770,000	Southern California Edison Co.	1981
•	Eastern Desert Plant: Unit 2	770,000	Southern California Edison Co.	1982
COLORADO				
Platteville	Ft. St. Vrain Nuclear Generating Station	330,000	Public Service Co. of Colorado	1973
CONNECTICUT				
Haddam Neck	Haddam Neck Plant	575,000	Conn. Yankee Atomic Power Co.	1968
Waterford	Millstone Nuclear Power Station: Unit 1	652,100	Northeast Utilities	1971
Waterford	Millstone Nuclear Power Station: Unit 2	828,000	Northeast Utilities	1974
Waterford	Millstone Nuclear Power Station: Unit 3	1,150,000	Northeast Utilities	1979
DELAWARE				
Summit	Summit Power Station: Unit 1	770,000	Delmarva Power & Light Co.	1979
Summit	Summit Power Station: Unit 2	770,000	Delmarva Power & Light Co.	1982
FLORIDA				
Florida City	Turkey Point Station: Unit 3	693,000	Florida Power & Light Co.	1972
Florida City	Turkey Point Station: Unit 4	693,000	Florida Power & Light Co.	1973
Red Level	Crystal River Plant: Unit 3	825,000	Florida Power Corp.	1973
Ft. Pierce	St. Lucie Plant: Unit 1	801,000	Florida Power & Light Co.	1975
Ft. Pierce	St. Lucie Plant: Unit 2	801,000	Florida Power & Light Co.	1978
GEORGIA				
Baxley	Edwin I. Hatch Nuclear Plant: Unit 1	786,000	Georgia Power Co.	1974
Baxley	Edwin I. Hatch Nuclear Plant: Unit 2	795,000	Georgia Power Co.	1978
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 1	1,121,000	Georgia Power Co.	1980
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 2	1,121,000	Georgia Power Co.	1981
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 3	1,121,000	Georgia Power Co.	1982
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 4	1,121,000	Georgia Power Co.	1983
ILLINOIS				
Morris	Dresden Nuclear Power Station: Unit 1	200,000	Commonwealth Edison Co.	1960
Morris	Dresden Nuclear Power Station: Unit 2	809,000	Commonwealth Edison Co.	1970
Morris	Dresden Nuclear Power Station: Unit 3	809,000	Commonwealth Edison Co.	1971
Zion	Zion Nuclear Plant: Unit 1	1,050,000	Commonwealth Edison Co.	1973
Zion	Zion Nuclear Plant: Unit 2	1,050,000	Commonwealth Edison Co.	1974
Cordova	Quad-Cities Station: Unit 1	800,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1972
Cordova	Quad-Cities Station: Unit 2	800,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1972
Seneca	LaSalle County Nuclear Station: Unit 1	1,078,000	Comm. Ed. Co.-Ia.	1977
Seneca	LaSalle County Nuclear Station: Unit 2	1,078,000	Comm. Ed. Co.-Ia.	1978
Bryon	Byron Station: Unit 1	1,120,000	Comm. Edison Co.	1979
Bryon	Byron Station: Unit 2	1,120,000	Comm. Edison Co.	1980
Braidwood	Braidwood: Unit 1	1,100,000	Comm. Edison Co.	1979
Braidwood	Braidwood: Unit 2	1,100,000	Comm. Edison Co.	1980
Clinton	Clinton Nuclear Power Plant: Unit 1 •	950,000	Illinois Power Co.	1980
Clinton	Clinton Nuclear Power Plant: Unit 2	950,000	Illinois Power Co.	1982
INDIANA				
Dune Acres	Bailly Generating Station	660,000	Northern Indiana Public Service Co.	1977
IOWA				
Palo	Duane Arnold Energy Center: Unit 1	569,000	Iowa Electric Light and Power Co.	1974
LOUISIANA				
Taft	Waterford Generating Station	1,113,000	Louisiana Power & Light Co.	1977
St. Francisville	River Bend Station: Unit 1	934,000	Gulf States Utilities Co.	1980
St. Francisville	River Bend Station: Unit 2	934,000	Gulf States Utilities Co.	1982
MAINE				
Wiscasset	Maine Yankee Atomic Power Plant	790,000	Maine Yankee Atomic Power Co.	1972

Figure 1. Nuclear power reactors in the United States, September 30, 1973—continued

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	COMMERCIAL OPERATION
MARYLAND				
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 1	845,000	Baltimore Gas and Electric Co.	1974
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 2	845,000	Baltimore Gas and Electric Co.	1975
Nanjemoy	Douglas Point Project: Unit 1	1,178,000	Potomac Electric Power Co.	1980
Nanjemoy	Douglas Point Project: Unit 2	1,178,000	Potomac Electric Power Co.	1981
MASSACHUSETTS				
Rowe	Yankee Nuclear Power Station	175,000	Yankee Atomic Electric Co.	1961
Plymouth	Pilgrim Station: Unit 1	664,000	Boston Edison Co.	1972
Plymouth	Pilgrim Station: Unit 2	1,180,000	Boston Edison Co.	1980
MICHIGAN				
Big Rock Point	Big Rock Point Nuclear Plant	70,300	Consumers Power Co.	1965
South Haven	Palisades Nuclear Power Station	700,000	Consumers Power Co.	1971
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 2	1,123,000	Detroit Edison Co.	1976
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 3	1,125,000	Detroit Edison Co.	1979
Bridgman	Donald C. Cook Plant: Unit 1	1,060,000	Indiana & Michigan Electric Co.	1974
Bridgman	Donald C. Cook Plant: Unit 2	1,060,000	Indiana & Michigan Electric Co.	1975
Midland	Midland Nuclear Power Plant: Unit 1	492,000	Consumers Power Co.	1980
Midland	Midland Nuclear Power Plant: Unit 2	818,000	Consumers Power Co.	1979
St. Clair County	Greenwood: Unit 2	1,240,000	Detroit Edison Co.	1980
St. Clair County	Greenwood: Unit 3	1,240,000	Detroit Edison Co.	1981
Quanicassee	Quanicassee: Unit 1	1,150,000	Consumers Power Co.	1981
Quanicassee	Quanicassee: Unit 2	1,150,000	Consumers Power Co.	1982
MINNESOTA				
Monticello	Monticello Nuclear Generating Plant	545,000	Northern States Power Co.	1971
Red Wing	Prairie Island Nuclear Generating Plant: Unit 1	530,000	Northern States Power Co.	1973
Red Wing	Prairie Island Nuclear Generating Plant: Unit 2	530,000	Northern States Power Co.	1974
MISSISSIPPI				
Port Gibson	Grand Gulf Nuclear Station: Unit 1	1,290,000	Mississippi Power & Light Co.	1979
Port Gibson	Grand Gulf Nuclear Station: Unit 2	1,290,000	Mississippi Power & Light Co.	1981
NEBRASKA				
Fort Calhoun	Ft. Calhoun Station: Unit 1	457,400	Omaha Public Power District	1973
Brownville	Cooper Nuclear Station	778,000	Nebraska Public Power District and Iowa Power and Light Co.	1974
NEW HAMPSHIRE				
Seabrook	Seabrook Nuclear Station: Unit 1	1,200,000	Public Service of N.H.	1979
Seabrook	Seabrook Nuclear Station: Unit 2	1,200,000	Public Service of N.H.	1981
NEW JERSEY				
Toms River	Oyster Creek Nuclear Power Plant: Unit 1	640,000	Jersey Central Power & Light Co.	1969
Forked River	Forked River Generating Station: Unit 1	1,070,000	Jersey Central Power & Light Co.	1978
Salem	Salem Nuclear Generating Station: Unit 1	1,090,000	Public Service Electric and Gas, N.J.	1975
Salem	Salem Nuclear Generating Station: Unit 2	1,115,000	Public Service Electric and Gas, N.J.	1976
Bordentown	Newbold Nuclear Generating Station: Unit 1	1,067,000	Public Service Electric and Gas, N.J.	1981
Bordentown	Newbold Nuclear Generating Station: Unit 2	1,067,000	Public Service Electric and Gas, N.J.	1982
Little Egg Inlet	Atlantic Generating Station: Unit 1	1,150,000	Public Service Electric and Gas, N.J.	1980
Little Egg Inlet	Atlantic Generating Station: Unit 2	1,150,000	Public Service Electric and Gas, N.J.	1981
NEW YORK				
Indian Point	Indian Point Station: Unit 1	265,000	Consolidated Edison Co.	1962
Indian Point	Indian Point Station: Unit 2	873,000	Consolidated Edison Co.	1973
Indian Point	Indian Point Station: Unit 3	965,000	Consolidated Edison Co.	1974
Scriba	Nine Mile Point Nuclear Station: Unit 1	625,000	Niagara Mohawk Power Co.	1969
Scriba	Nine Mile Point Nuclear Station: Unit 2	1,080,000	Niagara Mohawk Power Co.	1978
Ontario	R. E. Ginna Nuclear Power Plant: Unit 1	470,000	Rochester Gas & Electric Co.	1970
Brookhaven	Shoreham Nuclear Power Station	819,000	Long Island Lighting Co.	1977
Scriba	James A. Fitzpatrick Nuclear Power Plant	821,000	Power Authority of State of N.Y.	1973
•		1,150,000	Long Island Lighting Co.	1981
NORTH CAROLINA				
Southport	Brunswick Steam Electric Plant: Unit 1	821,000	Carolina Power and Light Co.	1975
Southport	Brunswick Steam Electric Plant: Unit 2	821,000	Carolina Power and Light Co.	1974
Cowens Ford Dam	Wm. B. McGuire Nuclear Station: Unit 1	1,180,000	Duke Power Co.	1976
Cowens Ford Dam	Wm. B. McGuire Nuclear Station: Unit 2	1,180,000	Duke Power Co.	1977
Bonsal	Shearon Harris Plant: Unit 1	915,000	Carolina Power & Light Co.	1978
Bonsal	Shearon Harris Plant: Unit 2	915,000	Carolina Power & Light Co.	1979
Bonsal	Shearon Harris Plant: Unit 3	915,000	Carolina Power & Light Co.	1980
Bonsal	Shearon Harris Plant: Unit 4	915,000	Carolina Power & Light Co.	1981
•	–	1,200,000	Duke Power Co.	1981
•	–	1,200,000	Duke Power Co.	1982
•	–	1,200,000	Duke Power Co.	1983
•	–	1,200,000	Duke Power Co.	1984
•	–	1,200,000	Duke Power Co.	1985
•	–	1,200,000	Duke Power Co.	1986
OHIO				
Oak Harbor	Davis-Besse Nuclear Power Station	906,000	Toledo Edison-Cleveland Electric Illuminating Co.	1975
Perry	Perry Nuclear Power Plant: Unit 1	1,205,000	Cleveland Electric Illuminating Co.	1979
Perry	Perry Nuclear Power Plant: Unit 2	1,205,000	Cleveland Electric Illuminating Co.	1980
Moscow	Wm. H. Zimmer Nuclear Power Station: Unit 1	810,000	Cincinnati Gas & Electric Co.	1977

Figure 1. Nuclear power reactors in the United States, September 30, 1973—continued

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	COMMERCIAL OPERATION
OREGON				
Prescott	Trojan Nuclear Plant: Unit 1	1,130,000	Portland General Electric Co.	1975
Boardman		1,200,000	Portland General Electric Co.	1980
PENNSYLVANIA				
Peach Bottom	Peach Bottom Atomic Power Station: Unit 1	40,000	Philadelphia Electric Co.	1967
Peach Bottom	Peach Bottom Atomic Power Station: Unit 2	1,065,000	Philadelphia Electric Co.	1973
Peach Bottom	Peach Bottom Atomic Power Station: Unit 3	1,065,000	Philadelphia Electric Co.	1974
Pottstown	Limerick Generating Station: Unit 1	1,065,000	Philadelphia Electric Co.	1979
Pottstown	Limerick Generating Station: Unit 2	1,065,000	Philadelphia Electric Co.	1980
Shippingport	Shippingport Atomic Power Station: Unit 1	90,000	Duquesne Light Co.	1957
Shippingport	Beaver Valley Power Station: Unit 1	852,000	Duquesne Light Co. Ohio Edison Co.	1974
Shippingport	Beaver Valley Power Station: Unit 2	852,000	Duquesne Light Co. Ohio Edison Co.	1978
Goldsboro	Three Mile Island Nuclear Station: Unit 1	819,000	Metropolitan Edison Co.	1974
Goldsboro	Three Mile Island Nuclear Station: Unit 2	905,000	Jersey Central Power & Light Co.	1976
Berwick	Susquehanna Steam Electric Station: Unit 1	1,052,000	Pennsylvania Power and Light	1979
Berwick	Susquehanna Steam Electric Station: Unit 2	1,052,000	Pennsylvania Power and Light	1981
Fuller	Fulton Generating Station: Unit 1	1,140,000	Philadelphia Electric Co.	1981
Fuller	Fulton Generating Station: Unit 2	1,140,000	Philadelphia Electric Co.	1983
SOUTH CAROLINA				
Hartsville	H. B. Robinson S.E. Plant: Unit 2	700,000	Carolina Power & Light Co.	1971
Seneca	Oconee Nuclear Station: Unit 1	886,000	Duke Power Co.	1973
Seneca	Oconee Nuclear Station: Unit 2	886,000	Duke Power Co.	1973
Seneca	Oconee Nuclear Station: Unit 3	886,000	Duke Power Co.	1974
Broad River	Virgil C. Summer Nuclear Station: Unit 1	900,000	South Carolina Electric & Gas Co.	1978
Lake Wylie	Catawba Nuclear Station: Unit 1	1,180,000	Duke Power Co.	1979
Lake Wylie	Catawba Nuclear Station: Unit 2	1,180,000	Duke Power Co.	1980
TENNESSEE				
Daisy	Sequoyah Nuclear Power Plant: Unit 1	1,140,000	Tennessee Valley Authority	1975
Daisy	Sequoyah Nuclear Power Plant: Unit 2	1,140,000	Tennessee Valley Authority	1976
Spring City	Watts Bar Nuclear Plant: Unit 1	1,169,000	Tennessee Valley Authority	1978
Spring City	Watts Bar Nuclear Plant: Unit 2	1,169,000	Tennessee Valley Authority	1978
Oak Ridge	Clinch River Breeder Reactor Plant	400,000	Project Management Corporation	1980
TEXAS				
Glen Rose	Commanche Peak Steam Electric Station: Unit 1	1,150,000	Texas Utilities Services Inc.	1980
Glen Rose	Commanche Peak Steam Electric Station: Unit 2	1,150,000	Texas Utilities Services Inc.	1982
Jasper	Blue Hills: Unit 1	918,000	Gulf States Utilities	1980
Wallis	Allens Creek: Unit 1	1,150,000	Houston Lighting & Power Co.	1980
Wallis	Allens Creek: Unit 2	1,150,000	Houston Lighting & Power Co.	1982
Bay City	South Texas Project	1,250,000	Central Power & Light Co.	1980
Bay City	South Texas Project	1,250,000	Central Power & Light Co.	1982
VERMONT				
Vernon	Vermont Yankee Generating Station	513,930	Vermont Yankee Nuclear Power Corp.	1972
VIRGINIA				
Gravel Neck	Surry Power Station: Unit 1	788,000	Virginia Electric & Power Co.	1972
Gravel Neck	Surry Power Station: Unit 2	788,000	Virginia Electric & Power Co.	1973
Mineral	North Anna Power Station: Unit 1	898,000	Virginia Electric & Power Co.	1974
Mineral	North Anna Power Station: Unit 2	898,000	Virginia Electric & Power Co.	1975
Mineral	North Anna Power Station: Unit 3	907,000	Virginia Electric & Power Co.	1977
Mineral	North Anna Power Station: Unit 4	907,000	Virginia Electric & Power Co.	1978
Gravel Neck	Surry Power Station: Unit 3	882,000	Virginia Electric & Power Company	1980
Gravel Neck	Surry Power Station: Unit 4	882,000	Virginia Electric & Power Company	1981
WASHINGTON				
Richland	N-Reactor/WPPSS Steam	800,000	Atomic Energy Commission	1966
Richland	WPPSS No. 1	1,120,000	Washington Public Power Supply System	1980
Richland	WPPSS No. 2	1,103,000	Washington Public Power Supply System	1977
Satsop	WPPSS No. 3	1,200,000	Washington Public Power Supply System	1981
WISCONSIN				
Genoa	Genoa Nuclear Generating Station	53,200	Dairyland Power Cooperative	1971
Two Creeks	Point Beach Nuclear Plant: Unit 1	497,000	Wisconsin Michigan Power Co.	1970
Two Creeks	Point Beach Nuclear Plant: Unit 2	497,000	Wisconsin Michigan Power Co.	1972
Carlton	Kewaunee Nuclear Power Plant: Unit 1	541,000	Wisconsin Michigan Power Co.	1973
*		900,000	Wisconsin Electric Power Co.	1980
*		900,000	Wisconsin Electric Power Co.	1982
PUERTO RICO				
Puerto De Jobas	Aguirre Nuclear Power Plant	583,000	Puerto Rico Water Resources Authority	1979

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* Site not selected.

*	–	1,128,000	Tennessee Valley Authority	1980
*	–	1,128,000	Tennessee Valley Authority	1981
*	–	1,128,000	Tennessee Valley Authority	1980
*	–	1,128,000	Tennessee Valley Authority	1981

Figure 1. Nuclear power reactors in the United States, September 30, 1973—continued

Reported Nuclear Detonations, November 1973

(Includes seismic signals presumably from foreign nuclear detonations)

There were no reported nuclear detonations for the United States for November 1973, and no seismic signals were recorded during this month.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U.S. nuclear detonations may be obtained upon request from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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Synopses of reprots, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their fines.

VERTICAL DISTRIBUTION OF FALLOUT CESIUM-137 IN CULTIVATED SOILS. ***J. C. Ritchie*** **and** ***J. R. McHenry. Radiation Data and Reports, Vol. 14, December 1973,*** **pp. 727–728.**

Fallout cesium-137 was found to be evenly distributed in the upper 15-20 cm of cultivated soils of five watersheds in the mid-United States. This distribution pattern is markedly different from the vertical distribution of cesium-137 in noncultivated soils.

KEYWORDS: Cesium-137, fallout, mid-United States, soil, watershed.